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Agathiyan and Tamil Literature

By

S. S. Bharati

(Annamalai University)

So many and diverse are the myths associated with the name of Agathiyan in Tamil Literature, that it is now exceedingly difficult if not impossible to discover whether any and what warrant exists to postulate a historic background for all or any of them. Legends, unrelated in their origin and irreconcilable in their history, have now for ages been so indiscriminately interwoven by a legion of writers that the amalgam, even under the great weight of volume and with the concretion of time, retains and betrays the tell-tale traits of a hotch-potch. Writers have vied with each other to seize and improve upon tales of different ages and diverse cultures to present a progenitor for the hierarchy of Tamil authors, so hoary that now every flower and fruit in every branch of the tree of literature is pompously given a pedigree tracing it to the magic seed-bed of the fertile and versatile mind of this mystic personage lost in the hazy but fascinating fairy-land of mythology.

Recently some research scholars have started the hunt, and are turning the glare and searchlight of modern criticism on these tales with a view to unravel this labyrinth of 'Agasthiya' myth ; and they are now deftly threading their devious turns to run this fairy fox down in his mystic hole.

Subjected to a strictly logico-historical electrolysis, if I may use such a phrase, this age-long mythopoeic compound resolves into a

three-fold spectral complex mytho-groups, each suggesting that it should be an exaggerated and refracted variant of the other:—viz (*i*) there is first the sheaf of ' Agasthiya ' legends in the Aryan or Sanskrit literature of the Trans-Vindhyan origin; (*ii*) there is then the agglom of 'Agathiyar' myths of the Tamil literature; (*iii*) and there is also the transmarine clump of Agasthiyan legends of the Indonesian and Indo-china folk-lores and literature. Not one of these three is elemental or unitary; they all offer self-suggestive indications that each is an ill-assorted fossilised cluster betraying its incongrous and clumsy admixture.

Taking the last as first, the Malayan and Javanese legend-groups current in both the peninsular and archipelagic regions may at once be summarily disposed of as calling for no special attention for purposes of our investigation here. They bear on their very face the impress of their foreign origin. They are not the indigenous products of those parts. They bear their self-revealing label of adulteration and admixture of two sets of imported legends, unequivocally proving their twofold foreign factories, Aryan and Tamilian. They offer nothing original or intricate worthy of inquiry, and can add nothing of value to the study of these legends in their original manufactories in the North Aryan and the Southern Tamil regions of our Indian Sub-Continent. We may therefore pass them over without any detriment to the purpose of this thesis, and proceed to the next group.

In the Sanskrit Literature we trace three or more personages of the name of Agasthiya, each related or referred to in different books of different ages. There is the oldest Pre-Valmiki Agasthiya of the Vedic Aryan clans eulogised and immortalised in the Rig Veda, which speaks of this powerful clan-leader and of his patrician spouse Lopamudra among the pioneers of the early Aryan enterprise in the Gangetic valleys. We next hear of two or more Agasthiyas in the epic age. Even the Ramayana of Valmiki mentions two distinct Agasthiyas as residing respectively at two separate far-off places. The first is the elder brother of Sudarsana Maharishi and veteran leader of the hardy daring Aryan colonists bravely pushing forward into the wild country south of the Vindhya mountains. He was captaining the vanguard of this pioneering hermit order of Templars then entrenched in their southernmost outpost a little to the north of Panchavati or the modern Nasik in the north-western valley above the Narmadha and crusading against the non-Aryan native tribes of those uncivilised wilds. He welcomes Rama in his aimless jungle wanderings, persuades him to forsake his

peaceful role of penance and pilgrimage, and incites him to fight and exterminate the troublesome militant tribal chiefs who have been hostile and unaccommodating to the advancing Aryan settlers in those regions. This great fighting Rishi is eulogised by Valmiki in superb language of poetry glowing with all the warmth and admiration of a great Aryan poet for the valiant Knight Templar who championed, promoted and advanced the cause of Aryan culture in far-off foreign fields. This is found in the Aranya Kandam of Valmiki, sargas 11 and 12.

We next hear of another Agasthiya in the Kishkinda Kandam of both Valmiki's and Kamban's Ramayanams as a peaceful learned hermit domiciled in the southern end of the far-flung spur of the Malaya hill near its dip into the southern sea. There is no mistaking this latter personage for the former Agasthiya near Panchavati. There is nothing in the meagre reference to this hermit of the Southern or Dravidian domicile even to suspect any possible identity of the latter one with the former. There is more than one canto in the Aranya Kandam in both the epics devoted in praise of the enterprise and activities, patriotic ardour and perfervid ritualistic Vedic religion of the Aryan Rishi in the northern jungles. But in the Kishkinda Kandam, there is but the barest and passing reference to his southern namesake, merely mentioning him as a montanic monk residing in one of the landmarks in the extreme southern edge of the civilised Pandian kingdom in Dravida or the Southern peninsula to be visited by the reconnoitering platoon of the simian army of Sugriva, sent to ransack the southern regions in search of Sita ravished by Ravana. The poet's language leaves no doubt whatever as to the different identity of these two men. Not only is there not the remotest hint or suggestion in the latter case that this southern hermit was an Aryan or was following and practising the Aryan religious rites. But there is also clear and positive indication that the poet does not want the readers to confuse these two names. As if to warn the readers against any possible surmising that the militant Aryan Agasthiya near the Panchavati might betake himself in some magic aerial conveyance to his own far-off sequestered Pothian ashram for rest and relaxation in the intervals of his strenuous campaigns in his northern camp, both Valmiki and Kamban emphasise in the most unequivocal language in each context that the two Agasthiyas, they were referring to, were permanent residents in their respective resorts:—one a veteran Templar with his staff engaged in battling or bivouacking amidst the non-Aryan tribes near Panchavati ; and the other a mere recluse retiring to his mountain resort for restful repose and quiet contemplation in the midst of silence and solitude—Vide Valmiki's Ramayana, Aranya

Kandam, Sargas 11 and 12, and Kishkinda Kandam Sarga 41, and Kamba Ramayanam, Kishkinda Kandam, Nadavitta Patalam, stanza 31 :

"தென்றமிழ் நாட்டகன் பொதியிற்றிரு முனிவன் தமிழ்ச்சங்கஞ் சேர்கிற்றீரேல்
என்று மவனுறைவிடமா மாதலாலம்மலையை யிடத்திட்டேகி"

Thus it is crystal clear for all fair-minded readers that Valmiki means, and mentions about, two separate Agasthiyars in the two regions separated by over twice-four hundred miles of wild and impenetrable forests. It is a moot question therefore as to whether the latter Agathiya in the southern Pothia home is also an Aryan vagrant ascetic of the same gothra or of the eponymous name as that of his northern namesake that drifted to and settled contentedly in the lone Pothia hills, averse to and away from all contact with the Pandian civilisation of which Valmiki speaks highly in the same context or whether he could be a Tamil seer and saint of the well-known 'Ariwar' order, whose fame had travelled far to the north-Aryan lands, and evoked an echo in the epic of Valmiki. It looks as if the latter hypothesis is more probable.

Let us pause till we probe the other Tamil counterpart of this Agasthiya legends. In the whole range of the earliest classics of the Sangam age, we meet with no name, saintly or secular, of any person by the name of Agathiyan. The reference in the 11th verse in Paripadal gives us no name whatever. It simply speaks of the star said to be named after the Pothyan-recluse. Yet this proves that even so early as at the time of Nallanthuvanar, the author of this verse and of *Neithalkali,* about two millenniums ago, the Tamils venerated the memory of some great personage whose name had already become a legend, sufficiently old for them to fancy he had become a star continuing to twinkle his blessings on his race yet living on earth. What interests us here is that this stellar saint is spoken of as the hermit that once had his home in the Pandiyan's Pothiya hills. That therefore the early Tamils even of the third Sangam age believed in some personage of pre-classic age of the order of Ariwars or seers, known to and frequently spoken of in all classics of the Sangam period, is thus fairly well established. That he should have earned great fame, and left a great name to be remembered and revered in the Tamil country, is also clear. Otherwise he could not have been thus canonized in *Paripadal*. That his should also have been a great name among the literary stars of the pre-classic age, and that he should have contributed no small share by his literary activities in stablising and standardising the Tamil grammar and literature are also obvious

from the fact that unbroken traditions in *Tamilaham* make him the unquestioned patriarch of the literary hierarchy in *Tamilaham.* If his name and fame should have crystalised into a hoary legend by the age of *Kalithogai* and *Paripadal* 2,000 years ago, he should have lived and laboured for Tamil, centuries before the 3rd Sangam Sun began to set. Tholkappiar nowhere makes mention of this Tamil savant specifically of course. But that in itself will not suffice to negative the existence of a pre-Tholkappian Leviathan of Tamil literature. For, Tholkappiar does not claim to be the father of Tamil Grammar himself. He expressly and frequently speaks of a galaxy of literati, who set standards for him both in poetry and grammar—*Ilakkiam and Ilakkanam.* On the other hand the strange absence of any reference to any Agasthiya in his standard work significantly suggests that the later hazy myth connecting Tholkappiar and Agasthiyar as master and student has no valid warrant whatever in fact. It is not probable or natural to expect such ingratitude or insolent discourtesy in the author of the great Tamil grammar deliberately to consign his far-famed master to oblivion. Even were the foolish unnatural story of the bickerings between the master and his pupils taken as adequately accounting for his ignoring his great guru, his contemporary co-students like Panamparar have no such reason or justification to share Tholkappiar's guilt and conspiracy to filch their illustrious master of his fair fame. They dared not and could not hope to banish his memory from Tamilaham. If there were any the least truth in this story of the legendary father of Tamil grammar being a contemporary and teacher to Tholkappiar and his collegiate colleagues, surely they should have felt it their proudest privilege to glory in their discipleship under such a master, and would have been loudest in chanting his praise in all their works as adding lustre thereto. I am therefore of opinion that the Pothian sage, sung by Nallanthuvanar in *Paripadal* was not a contemporary, but lived and died before Tholkappiar ; that his name must have become a legend to the literati of his age. Probably this pre-classic patriarch of Tamil Vyakarnins was not an Aryan at all. He lived too far away in the remote past to admit of his being a solitary Aryan adventurer settling down in a sequestered nook of the Tamil Parnassus after braving the impenetrable interminable wildernesses intervening between the northern Aryavartha beyond the Vindhya and the civilised Tamilaham in extreme south of the Indian continent. He must have been a great scholar on all accounts. If he swam across the wild forests infested by tribes as savage as the beasts that were prowling there and reached at last a land whose civilisation caught his own fancy and the admiration of the greatest and earliest Aryan epic poet, and if he also fell in such love with the language and literature of the new land he

came into that he set himself to learn enough of it to become a master-grammarian in that new language, is it natural or probable that he thereafter grew such a cynic and misanthropist as to seek a voluntary banishment from all contact with civilisation in that land and preferred to vegetate in the lonely forests of Pothia Hills in the only company of roving wild beasts roaring to the echo of the torrential cascades of jungle-streams ? No ; this cannot be. The truth must be this mythical Tamil grammarian, if ever he were a human personality, was the tallest among Tamil poppies of a remote past. And he left a name too great to be forgotten, and so beloved as to serve as a nucleus for many a myth to be woven around it by his fond and admiring posterity. The accretions of legends around his name grew thick and fast, and shrowded the memory of the original hero in successive layers of different density and differing hues that it is now very difficult, if not impossible, to penetrate the crust and see the kernel in its reality. We can at this distant time only inductively infer all about this pre-classic Leviathan, even whose fossilized skeleton is sunk so deep down in dark distance as now to be visualised only through the dim and refractory glimmer of the cavernous past.

I now seek leave to offer my suggestion. I am well aware it cannot be now more than a mere suggestion, to be worked out by future fuller research. There was perhaps in the pre-classic Tamilaham, long before the Aryan contact, a hoary sage and savant by the name of 'Agathiyan,' a name unconnected with the Sanskrit 'Agasthiya.' He was of the order of 'Ariwar' or seers, so well-known and revered in all the early Tamil classics. His life and labours left a sweet memory embalmed by later legends and enshrined in later literary works in Tamilaham. The post-Tholkappian miracle-mongering credulity loved to weave around this hoary name many a legend that tickled its vanity or pandered to its new-fangled love for Aryanised lores. Metamorphosing Tamilian names into their fanciful Aryan mythical equivalents is a well-known process that started early and was long at work in Tamilaham. Familiar and significant instances are not wanting to clinch this truth. Who does not know how the Tamil 'Muruga' came to be installed as the 'Subramania,' and how the Tamilian 'Ayai' (ஐயை) was metamorphosed into the 'Durgai' and Parvathi in the Aryan pantheon ? Even 'mayon' and 'mal' are believed to be old pre-Aryan Tamil names, subsequently identified with the later Aryan Sungod, Vishnu. In the course of Aryanising Tamil culture in the post-Tholkappian Tamilaham, not only deities lost their Tamilian identity and got merged with some corresponding Aryan gods, but fertile ingenuity never spared itself in finding even for many a familiar name of Tamil lands, rivers

and persons, fancied Aryan correlatives, and in inventing elaborate heraldic pedigrees in high sounding Aryan phraseology. 'Ven-Kadu' or white forest is transformed into Svetaranyam; 'Tan-Porunai' becomes Tambraparni. The oldest Tamil dynasty of the 'Pandians' derivable from the Tamil root 'Pandai' (='old') is now linked with the Aryan 'Pandavas'. Therefore, that the Tamil 'Agathiyan' also could easily be turned into the Sanskrit 'Agasthiya' need not tax our faith very considerably.

Either the story about Agathiya being the patriarch of the Tamil literati is altogether to be rejected as a deliberate concoction; or it is to be taken that there was some real warrant and factual background for this Agathiyan mythology in Tamilaham. With the available evidence and the long unbroken traditions in literature, it is rather more probable than otherwise that there lived some great savant at the dawn of the primeval history of Tamil literature to answer to the legend-hallowed hero of the Pothiyil hill. Otherwise the whole mythologic edifice would be only a castle in the air. And the entire Tamil race, both the lay mass and the cultured scholars of those early times, could not have accepted this gilt whistle, and apotheosized a mere Aryan Rishi as the father of the Tamil Literature. It is still more probable that he was a Tamilian, who adorned the Tamilaham with his wide erudition, and great talents, and high literary attainments in the hoary past long prior to the advent of the Aryan settlers in this part of the country. The memory of this pre-historic Leviathan lingered through successive generations of his admiring countrymen, gradually mellowing in colour, contour and perspective, till a neophyte fancy fertilized by the fresh Aryan contacts in the later Sangam age seized hold of it and richly inlaid and filigreed it with a mythopoeic extravagance, and with lavish but indiscriminate use of all and sundry Aryan anachronisms.

Inventive imagination, quickened by the new contact of the Aryan culture, set to work. The accidental phonetic approximation of the names of this ancient Tamil savant and of the Aryan hero, 'Agathiyan' and 'Agasthiya'—perhaps first attracted; and the very love for emblazoning the memory of their first great savant naturally hastened and helped to complete the process of Aryanising this Tamil patriarch. Except on some such hypothesis, it is impossible to understand or to reconcile diverse incidents and episodes ascribed to this hallowed name in Tamil literature. But once we light upon this natural phenomenon so common and frequent in the history of the later hybrid culture of Tamilaham, every puzzle in this tangle of Agathiyan legends easily solves itself; and a glimpse of the unadorned Tamilian background becomes available to the students of the history of Tamil literature.

Of course fond fancy did not rest content with the mere merging of this Tamilian savant with the Aryan Rishi of Panchavati fame. Once set rolling in this exciting and exhilarating game, the snow-ball was not slow in gathering accretions. It swelled thick and fast; and its strange fascination simply served to stifle criticism and to secure for it the admiring and unquestioning acceptance of the enfeebled and enslaved Tamil minds. Not only the Panchavati Agasthiya's story was blended with the traditional tale of the father of Tamil grammar; but all the incidents of all the legendary heroes with the name of 'Agasthiya' in the Aryan lores were freely and lavishly woven into the fabric of this new Agasthiyan mythology in its new southern home. The plebian anchorite of Pandinad was not only enthroned at Nasik near Panchavati; and hailed as Rama's epic-host; but he was also wived with Lopamudra, the patrician spouse of the Rig Vedic Aryan clan-leader. The modern lore of Agathiyan myth is so artificial and thin-crusted that it falls to pieces at every touch of reason and criticism. Even if the Aryan Rishi at Nasik frequently aeroplaned to the Pothiyan paradise and miraculously eked out his span of life to preside over the first two successive Tamil Sangams or Academies, how could he resuscitate and recover the departed Vedic soul of Lopamudra from the Aryan 'Valhalla' back to be his spouse in the Tamil Parnassus? The obvious truth must be that the tradition of the Tamil academician was already in the Tamil land, and served handily for the myth-mongers to work upon. It was greedily seized hold of by the imaginative and ingenious new Aryan settlers, and was lavishly decorated and re-dressed to the delectation of his fond but indiscriminate post-sangam posterity with a rehash of all and sundry legends they could lay hands on about all Aryan heroes named 'Agasthiya' in their Sanskrit lores—no matter when, where, or howsoever they lived and died. The only tenable inference could be that the original of all this mythic plethora of fantastic tales in the later Tamil literature was a simple human literary hero of pre-Aryan Tamilaham, lionised by his admiring primitive fellow-Tamils for his unparalleled erudition and wide scholarship. This is made more than probable by the existence of traditions about many a Tamil 'Agathiyan' recorded in Tamil books, such as Muthoor Agathiyan' in செங்கோன் தரைச்செலவு. And Muthoor was a place in the submerged Pandinad south of Comorin. Persistent and consistent traditions of this kind current in the whole Tamil country and in Tamil literature about this pioneer and precursor of Tamil scholarship postulate the truth of a pre-Aryan Tamil scholar of such or similar name. And possibly there were more persons than one named 'Agathiyan' in early Tamilaham with some claim on the attention of posterity. Some one of them was the greatest; and his greatness attracted and wove round his name all the worthy incidents in the lives of his name-

sakes whose individualities were merged and lost in his halo in course of time, even as the many Aryan 'Agasthiyas' are indiscriminately mixed up in the later Sanskrit lores. And in the post-Sangam periods, the Aryan legends also combined with the integrated Tamil traditions still further to mystify and mythologise the story of this great Tamil savant. And now let us conclude this discussion with an attempt to study and reconstruct, if possible, some of the recorded statements in Tamil literature about this Tamil sage, which at present defy all sense or solution. Nachchinarkiniyar says as follows :—

"..........................அவரும் (அகத்தியனாரும்) தென்றிசைக்கட் போதுகின்றவர், கங்கையா ருழைச்சென்று காவிரியாரை வாங்கிக்கொண்டு, பின்னர் யமதக்கினியாருழைச்சென்று அவர் மகனார் திரணதூமாக்கினியாரை வாங்கிக்கொண்டு, புலத்தியனா ருழைச்சென்று அவருடன் பிறந்த குமரியார் உலோபாமுத்திரையாரை அவர் கொடுப்ப நீரேற்று இரீஇப் பெயர்ந்து, துவராபதிப் போந்து நிலங் கடந்த நெடுமுடியண்ணல் வழிக்கண் அரசர் பதினெண்மரையும் பதினெண்கோடி வேளிருள்ளிட்டாரையும் அருவாளரையுங் கொண்டுபோந்து, காடு கெடுத்து நாடாக்கிப் பொதியின்கணிருந்து, இராவணனைக் கந்தருவத்தாற் பிணித்து இராக்கதரை ஆண்டு இயங்காமை விலக்கி.........................."

Some of these later legends make this patriarch of Tamil literature not only an Aryan Rishi, but also makes him a pilgrim-father fetching a band of some chieftains and some surplus population of the Yadhava-clan from Lord Krishna's Dwaraka in the north. Nachchinarkiniyar, the great Brahman commentator of the medieval age, gives this sage also a victory in a musical contest with the ten-headed Rakshasa king, Ravana, of the southern Lanka. These statements require reconsideration in the light of the suggestion that this pioneer savant of pre-classical Tamilaham should have been a prehistoric native citizen of the southernmost Tamil kingdom. These statements of the great commentator, as they stand, simply refute one another. If this Agasthiya were a contemporary of Ravana, he should have lived in the second or Thretha Yuga ; and he could not possibly have gone to Dwaraka, which was built by Krishna of the Yadhava clan as his capital on the west coast for the first time only about the end of the third or Dwapara Yuga. If on the other hand he lived in Krishna's time, and peopled the southern Tamilaham with the unwanted clansmen of Krishna fetched from his new-found capital Dwaraka, surely he could have had nothing whatever to do with the famous Rama's rival, whose musical chants moved even the Lord of the Kailas Hill. Perhaps to avoid this obvious self-contradiction, the author of the Tamil brochure, called 'Velir-Varalaru,' naively suggests that the Ravana said to have been

defeated by Agasthya in a musical contest was not the king of Lanka slain by Rama, but must have been a later king of that name. This ingenious suggestion will be found to be of no avail, as elsewhere the legendary musical contest of Agasthiya is associated only with the king of Lanka sung by Valmiki. Even apart from this, there is a still more fatal objection to this naive theory making Agasthiya the captain and leader of the alleged Velir-immigrants from Dwaraka, who are said to be the forbears of all the later Tamil chieftains called in the Sangam classics as the munificent Velir-patrons of Tamil poets. Nachchinarkiniyar in the same context avers that this Agasthiya was also the contemporary of and master to the author of the most ancient extant classic Tamil grammar, known as Tholkappiam. This disciple of Agasthiya is said to be no other than Thranathumagni, son of Jamathagni, and brother to Parasurama. And we know from Valmiki that Parasurama was far senior to Rama, and was ousted by the hero of Valmiki's epic. The author of Tholkappiam, being Parasurama's brother, must also have lived about that time of Parasurama and Rama, referred to in Valmiki's Ramayana. That would make it possible for this Thranathumagni's master Agasthiya to meet Ravana, Rama's rival in the epic age. But for the same reason it would make it impossible for him to have gone to Krishna in Dwaraka on the alleged mission of fetching to Tamilaham the forefathers of the Tamil-Velirs. This whole legendary tangle thus bears on its very face its self-condemnation. A full one hundred millenniums form the interval between the times of Rama and Krishna. No human hero could live and span this gulf of time and achieve plaudits for his great deeds both as the host of Rama near the modern Nasik, as the vanquisher of Rama's enemy, Ravana, by his musical attainments, and also as the voluntary leader of the Yadhava colonists from Dwaraka in Krishna's time in the far-off southern Tamil country in the age of Mahabaratha wars at the fag-end of the third Yugam. These self-contradictory fictions are thus only to be stated to be rejected as baseless fabrications of unthinking, if not reckless, myth-mongers in the post-sangam Tamilaham.

The question arises therefore as to whether Agathiyar believed to be the pioneer in the field of Tamil scholarship, had anything whatever to do with the Pothia hills, if he were at all a historical personage in the pre-classical times. Here again it is plausible to hold that he might have settled down at the foot of the Pothia hills, and made all his fame as the most erudite scholar of his times by his incessant labour of love in promoting Tamil learning and culture. It is also probable that he was not originally a native of the woodlands of this famous hill, but came and settled there with an admiring band of Velir-youths romantically attach-

ed to him for his great Tamil learning. Nachchinarkiniyar must have heard some such legends about this migration and settlement of Agathiyar finally in the Pothia hills. But it is very probable that such legends as he heard and recorded in his commentary on the payiram of Tholkappiam came to him very much refracted by time and by reckless reports of unauthenticated traditions. Some phrases in the passages of Nachchinarkiniyar significantly suggest that the migration of the Tamil Agathiyar and his Velir-companions must be from somewhere south of Pothia hills, and not from the far-off northern Dwaraka. The commentator takes the words Nilam-Kadantha-Nedumudi-Annal (நிலங்கடந்த நெடுமுடி யண்ணல்) as referring only to Krishna, and the word Thuvarapathi (துவராபதி) as Krishna's capital Dwaraka. It is possible Nachchinarkiniyar heard of legends which suggested that this Agathiyar fetched his Velir-companions from a place then called துவராபதி with the sanction or encouragement of a sovereign described as நிலங்கடந்த நெடுமுடி யண்ணல். It is equally possible that our commentator believed these words as referring to, and therefore attributed them to, the Yadhava king of Dwaraka. He makes the same mistake in interpreting a similar passage in Maduraikanchi மதுரைக்காஞ்சி; (to wit) Nilam-tharu-thiruvil-nediyon நிலந் தருதிருவில் நெடியோன் as referring to Vishnu or Krishna. The author of Mathuraikanchi (மதுரைக்காஞ்சி) undoubtedly means by the latter phrase to indicate only the great Pandian king, who earned his great fame by his honoured connection with a great Tamil Sangam or academy he maintained in his own capital. Vidwan R. Raghava Ayyangar, Lecturer in the Research Branch of the Tamil Department of the Annamalai University, also interprets this passage of Mangudi Maruthanar (மாங்குடி மருதனார்) in Mathuraikanchi (மதுரைக்காஞ்சி) as referring only to the great Pandian king, and not to Vishnu or Krishna as Nachchinarkiniyar would take it to be. It is very useful in this connection also to remember that the great Pandian king, in whose court Tholkappiam is said to have received the Sangam imprimatur for his classical grammar, was known as Nilantharu-Thiruvir-Pandian (நிலந் தருதிருவிற் பாண்டியன்) (Vide Panambarar's Preface to Tholkappiam).

There were several places known by the name of Thuvarai in the Tamil country. Some such places were also existent in the old sea-swallowed Pandinad, south of the modern Cape Comorin. There was also 'Kapatapuram' the capital of the Pandian kings, and seat of the second sangam in the southern Pandian kingdom lost in the deluge; and 'Kapatapuram' taken to be a Sanskrit name by later post-sangam Aryan scholars might easily have been rendered into Dwarapathy or Thuvarapathy' (துவராபதி) as fair equivalent in Tamil of the supposed Sanskrit

name of the second Pandian capital. This possibility becomes a probability when we connect it with the recorded fact of destructive deluges engulfing vast territories of the Pandian kingdom, and of the Pandian king and his surviving citizen—followers migrating northward and settling down in the part of the Tamil country immediately north of Comorin and adjacent to the famous Pothia or Malaya hills (Vide Stanza No. 4 of Mullaikkali). Now putting two and two together, one may hazard the suggestion that the patriarch of Tamil literature, 'Agathiyar', might have migrated from the prediluvial Pandinad, might have visited the great Pandian capital Kapatapuram which was later rechristened as Thuvarapathy (துவாரபதி) and might have taken some adventurous Velir-chieftains attached to the court of the then Pandian king described as Nilam katantha Nedumudi Annal (நிலங்கடந்த நெடுமுடியண்ணல்). The words Nediyon (நெடியோன்) and Nedumudi Annal (நெடுமுடி யண்ணல்) may all mean the great Pandian king. Journeying northward, Agathiyar and his companions reached the foot of the Pothia hills, cleared the forests, and erected their cabin houses and settled there for good, charmed by their most picturesque and enchanting environments near the source of the classical river Porunai (பொருநை) of the Pandias now known as Thambaraparani, and making this montane-villa their permanent home from where they irradiated the fame and glory of Agathiyar's great erudition and scholarship in that primitive age. The fastnesses of the Pothia hills, before the advent of this adventurous band under the leadership of Agathiyar, would have been inaccessible to the ordinary inhabitants of the Tamil districts surrouding those hills and infested only by the denizens of the wilds. Gradually Agathiyar's companion-Velirs or chieftains should have dispersed themselves from this hill-dwelling of Agathiyar into the adjacent forest—countries and founded petty principalities. For, we hear from the Sangam classics that a Velir chieftain of the house of Ay was ruling over the tract of land almost close to where Agathiyar is said to have lived in the Pothia hills. We also hear of another Velir dynasty known as 'Avis' ruling over a small territory from a hill capital known by the name of that princely house, to wit, Avinankudi (ஆவிநன்குடி) now known as 'Palani' in the Palani hills.

Chronologically, if this Agathiyar were a contemporary of the king Nilantharu-Thiruvirpandian or Nilam-Kadantha-Nedumudi-Annal (நிலந் தருதிருவிற் பாண்டியன் or நிலங்கடந்த நெடுமுடி யண்ணல்) of Kapatapuram or Thuvarapathy (துவாராபதி), there would be nothing anachronistic in associating him with the author of Tholkappiam as master and disciple. For, as already mentioned above, Tholkappiam is said to have been introduced to the Sangam scholars only in the court of this

Pandian king. Nevertheless I am not inclined to accept this legendary relationship between Agathiyar and Tholkappiar as master and disciple for the reasons I have already discussed and set forth in the earlier paragraphs of this paper. I believe that Agathiyar had nothing whatever to do with Tholkappiar and his colleagues like Panamparar ; because these latter group of scholars make no mention of or reference to Agathiyar in any of their works, which we should expect them to do if they were themselves the pupils of this Agathiyar. It is very probable that Agathiyar was a senior scholar of pure Tamil extraction and the founder of a school of grammar and literature slightly different from that of Tholkappiar and his scholarly Brahman-compatriots. The latter group of scholars probably lived and laboured with the Tamil scholars of their time in the Pandian capital itself in the heart of the Pandian territory almost on the eve of the second deluge and the founding of the third sangam in modern Madura. On the other hand it is highly probable that Agathiyar lived at an earlier age as a literary recluse in the Pothia hills, far away from the din and bustle of both urban and rural life and activities in the Tamilaham of his times, and during the reign of an earlier ancestor of Tholkappiar's patron, but with the name same as or similar to his.

There are some scholars who are of opinion that all one hears in the entire range of Tamil literature about 'Agathiyar,' and all legends or tales that cluster around the name of 'Agathiyar' either as traditions among the Tamil people or as references in the Tamil poems, must be the wilful concoctions of some mendatious myth-mongers, and that the Agathiyan cult was deliberately started in comparatively recent times only as a counterblast to belittle the fame of the great Brahman author of the classic Tamil grammar, Tholkappiam. But this conjecture has not been proved to be, and I think it need not necessarily be, the only possible conclusion. It is equally probable to argue that the apotheosis of 'Agathiyar' into almost a deity, and canonising him as the star Canopus on the one hand, and ascribing to him all and sundry fabulous and irreconcilable incidents relating to different legendary personages in the lores of the Aryan mythology on the other, might have been the work of men whose object was to bury the prehistoric Tamilian precursor and pioneer in the field of Tamil Literature with a view to resurrect him as a great Aryan saint, who alone could shed lustre and light in the dim twilight on the horizon of Tamil culture. It is very true that all this mystery surrounding the name and life of Agathiyar, known as the patriarch of Tamil literature, is still befogged, and requires clearing by the light of further scrutiny and research. It is also true that the suggestion made in this paper may not suffice well to lift the veil and let

the flood of light into all the recesses of this Agathiyan myth. Yet I present my few thoughts in this paper on this question, only in the hope of inviting more accurate thinking, and more scientific review and reconsideration of all the materials bearing on this problem in the light of modern research and criticism, and with a view to ensure a truer perception and judgment in the sequel.

Nature Poetry in Kalidasa's Raghuvamsa

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The great rivers of India have also found their full meed of recognition in Kālidāsa's poetry. Poetry, myth and tradition are woven together in his references to the Ganges, the greatest and holiest of India's rivers. The puranic story of Bhagiratha bringing the Ganges from heaven for the purification of the ashes of his forefathers finds more than one reference. [1]Raghu followed by his army is compared to Bhagiratha with the Ganges behind him—the Ganges which had been released from the tangles of Siva's matted locks. [2]Kusa bowed to the waters of the tri-streamed river which rippled by the tossing of the boats on it and which secured the salvation of his ancestors who were turned to ashes by Kapila. The splendour of the waters noisily streaming on Atithi's head[3] shone like the Ganges falling on the head of Ishwara. The mythical origin of the Ganges from Vishnu's foot is referred to in the description of the Lord in the Tenth Canto.[4] "That speech issuing from the mouth of the Lord with the radiance of his teeth seemed to be the residual stream of the Ganges flowing upwards after issuing out of his foot." Describing the hermitage of Atri[5] the poet refers to the tradition that Anasūya directed the three-streamed river—which is as a chaplet in the matted hair of the three-eyed God, and the golden lotuses in whose waters are plucked by the hands of the seven sages—to flow into the grove for the daily bath of the ascetics. After defeating the Vangas[6] equipped with fleets, Raghu erected triumphal columns on the islands in the Ganges. Kusa[7] crossed a stream of the Ganges flowing from the Vindhyas, by a bridge of elephants. The gods singing the praises of Vishnu[8] state that though many paths lead to the goal of life they all converge in Him as the streams of the Ganges in the ocean. Referring to the dark waters of the Yamuna[9] and the milky waters of the Ganges the poet says that the sandal paste from the breasts

1. R. IV, 32.
2. R. XVI, 34.
3. R. XVII, 14.
4. R. X, 37.
5. R. XIII, 51.
6. R. IV, 36.
8. R. X, 26.
7. R. XVI, 33.
9. R. VI, 48.

of the Zenana ladies of Sushēna made the Jumna even at Mathūra to look as if she had joined the Ganges. The Ganges[10] in autumn with a narrow stream and with lotus-oblations on her broad sand-banks is compared to Kausalya with the infant Rama by her side. Pointing out the Ganges to Sita during their return from Lanka[11] Rama refers to the graceful, slow-flowing Ganges (Mandākini) with her clear, steady stream of waters and appearing thin in the distance like a string of pearls hanging from the neck of the earth near the mountain. When Kausalya[12] and Sumitra saw the returned exiles their cold tears of joy rushed into their scorching flow of tears of grief just as the cold flow of the streams descending from the Himalayas rushes into the summer-heated waters of the Ganges and the Sarayu. Sita,[13] during pregnancy, desired to re-visit the sacred hermitages on the Ganges, the hermitages abounding in Kusa grass where the offerings of wild rice were devoured by wild animals and where young hermit girls had been her companions. Lakshmana[14] about to abandon Sita was, as it were, prevented by the Ganges (flowing) in front of him, with her wave hands that were raised. But these pictures of the Ganges pale into insignificance when compared to Rama's[15] description of the sacred river in Canto XIII. Says Rama to his royal consort: " Behold this Ganges who having her stream broken by the ripples of the Yamuna seems here to be a necklace of pearls with interwoven emeralds suffusing them with their splendour ; there she is like a chaplet of white and blue lotuses ; in one place she resembles a row of royal swans to whom the *Mānasa* lake is dear while in another place she looks like a beautiful floor painted with black and white sandal ; in some spot her bosom is a fret-work of variegated moonbeams passing through leaves ; in another her surface looks like a fleece of white autumnal cloud with the blue sky visible through it in places ; in yet another spot she seems to be the body of Ishwara smeared over with ashes and decorated with black serpents. Those who bathe in the confluence of the two rivers are freed from re-birth even without the knowledge of the Supreme Spirit." Rarely does the poet display greater wealth of imagery in any other part of his writings.

The Sarayu (Gōgra), on whose southern bank Ayodhya is situated, finds frequent reference in the story of the Kings of Kōsala. Aja[16] gave up his body in the confluence of the rivers Ganges and Sarayu and

10. R. X, 69.
11. R. XIII, 48.
12. R. XIV, 3.
13. R. XIV, 28.
14. R. XIV, 51.
15. R. XIII, 54 to 58.
16. R. VIII, 95.

went to heaven to sport with his departed queen. Dasaratha[17] erected many golden sacrificial posts on the banks of the Tamasā and Sarayu. The Sarayu[18] greets the returning Rama with the cool breeze from her waves as if his own mother abandoned by the king were embracing him with her wave-like arms. As intelligence arises from the invisible principle so, say the Vedas, the Sarayu arises from the *Mānasa* lake the pollen from whose golden lotuses is enjoyed by the breasts of *Yaksha* women. Sacrificial posts adorn her banks and past the kingly city of Ayōdhya flow her holy waters which are rendered holier still by the ablutions of her kings after the horse-sacrifices. The kings of Ayōdhya have been dandled on her lap and nurtured on her waters; so she is the nurse of the Kōsala kings. On the banks of the Sarayu, Lakshmana[19] gave up his body by yoga and to the followers of Rama,[20] the Sarayu became the ladder to heaven on his ascension. The presiding deity[21] of Ayōdhya complains to Kusa and says: "I am pained to see the waters of the Sarayu with its sands denuded of oblation-offerings, with no contact with bathing materials and with her cane-bowers deserted." Returning to Ayōdhya from Kusāvati, Kusa[22] saw on the banks of the Sarayu hundreds of sacrificial posts fixed in square pedestals which had been set up by earlier Ikshvāku Kings.

Many others of the Indian rivers are also mentioned in the *Raghuvamsa*. Raghu crossed the Kapisā (Cossya)[23] on a bridge of elephants and reached Kalinga. Raghu's soldiers sported in the Kāvēri[24] while the Pāndya king gave him pearls of price (as if they were his collected fame) taken from the mouth of the Tāmraparni.[25] His conquests extended to the north-eastern end of India up to the Lauhitya[26] (Brahmaputra). Aja, on his way to the Vidarbha Kingdom, encamped on the bank of the Narmada.[27] Sunanda tells her royal mistress that the pleasure gardens of the King of Ujjain were fanned by the cool breezes from the Sipra,[28] a tributary of the Chambal and the Narmada (Rēva)[29] flows round the city of Māhishmati, the capital of the king of Anūpa. Returning with his bride, Aja met his enemies as the Sōna[30] with her surging waves meets the Ganges. Dasaratha erected sacrificial posts on the banks of the Tamasā[31] while Rama halted on its bank the first night

17. R. IX, 20.
18. R. XIII, 60 to 63.
19. R. XV, 95.
20. R. XV, 100.
21. R. XVI, 21.
22. R. XVI, 35.
23. R. IV, 38.
24. R. IV, 45.
25. R. IV, 50.
26. R. IV, 81.
27. R. V, 42.
28. R. VI, 35.
29. R. VI, 43.
30. R. VII, 36.
31. R. IX, 20.

of his exile. Rama rested on Sita's lap in the cane bowers on the banks of the Godavari[32] his cheeks being fanned by cool breezes. The hermitage of Agastya was on her banks. The hermits on the bank of the Yamuna[33] sought Rama's protection against the giant, Lavana. Later, Satrughna[34] built the city of Mathūra on her banks. The *chakravakas* in her waters made her look like the braid of hair of Mother Earth decorated with golden studs. Various features of rivers in general are also pressed into the service of his poetry by Kālidāsa. Indumati,[35] who had a navel as beautiful as an eddy, passed by the King of Sūrasēna as a river going to meet the sea passes by a mountain on her route. While Rama was returning from Mithila adverse winds harassed the army by their violence as the waters of a river[36] overflowing its banks cause trouble to dry land. Parasurama makes light of Rama's breaking of Janaka's bow because it had already been weakened by Vishnu: a light wind overturns a tree situated on a river bank[37] when its roots have been dug up by the current of the stream. Sūrpanaka approached Rama and Lakshmana in turn and rejected by the one she returned to the other as the stream of a river[38] touching both banks in turn. During Atithi's reign the subjects who were affluent under his father became still more prosperous as the rivers[39] full in Srāvana become still more so in Bhādrapada. Trade flowed freely on the rivers[40] as if they were domestic pools, over woods as if they were pleasure gardens, over mountains as if they were houses. During his reign Varuna made the water courses easily passable for sailors.

Nowhere in the world does nature appear in greater splendour than in this land stretching from the Himalayas to the Sētu, from the Brahmaputra to the Indus; and the wealth and variety of her life in hill and dale is surpassed by no other part of the globe. Nature in her changing beauty of day and night, morning and evening, seasons and equinoxes must provide incessant food for poetic reflection in this vast subcontinent of Asia and it is no exaggeration to say that Kālidāsa's poetry attains the meridian of its glory in the portrayal of nature. It is a happy thought of Professor Ryder to wish to see Darwin and Kālidāsa meet; the more one studies Kālidāsa's attitude to nature the more one realises the truth of Ryder's words; nature to Kālidāsa is a living presence and in immortal words he has painted the fellowship of man with nature in her varying moods.

32. R. XIII, 35, 36.
33. R. XV, 2.
34. R. XV, 28, 30.
35. R. VI, 52.
36. R. XI, 58.
37. R. XI, 76.
38. R. XII, 35.
39. R. XVI, 41.
40. R. XVII, 64, 81.

With the choicest pearls of poetry he adorns the beauty of an Indian morning. The morning song[41] of the minstrels to wake the son of Raghu on the day of Indumati's *swayamvara* endows it with princely beauty. As the day dawns the moon is pale and the bees moving among the lotuses seem to emulate the charm of Aja's vivacious countenance. Sweet is the breath of the morning which carries with it the fresh flowers from the stalks and the odour of the lotus. On the tender leaves red as coral, drops of dew glisten like pearls in the morning light and remind them of the charm of the prince's smile. The dawn is bright even before the mighty sun is up; the elephants are straining at their clanking chains, their tusks red in the morning sun as if they had pierced the sides of mountains red with minerals; the horses are sniffing at the rock salt placed before them; the flowers of the previous day are disarranged; the lamps have lost the halo of light surrounding them; the pet parrot is mimicking the song of the bards. Again, Kālidāsa compares the concourse of princes[42] and people after Indumati's choice to a lake in the morning with new-blown lotuses on one side and closed lilies on the other—the friends are smiling and jubilant on one side, the foes are blanched and pale on the other. The disappointed lovers of the princess[43] Indumati returned to their camps with their brightness dimmed as that of stars at early dawn. When Aja[44] met his enemies the stream of blood in the battlefield destroyed the dust as morning dispels darkness. His chariot[45] being covered by volleys of missiles Aja was discernible only by the topmost point of his banner as the forepart of the day shrouded in mist can be recognised only by the faintly shining sun. The prowess of Raghu[46] took off the flush of wine from the lotus faces of Yavana women as the rise of an untimely cloud hides the morning sunlight from lotuses. The brave Dasaratha[47] woke up in the morning in a forest glade having slept in the open away from his retinue and he enjoyed the sound of the flapping of wild elephants' ears and the melodious warblings of birds. To him these were but drums and music. A delightful autumn (Sarad) morning[48] with golden sunshine and full-blown lotuses resembles the lotus-eyed Vishnu dressed in bright raimant who delights the eyes of Yōgins. The soft rays[49] of the morning sun are divided between sun and earth; so was the *caru* divided by Dasaratha between Kausalya and Kaikayi. The beauty of a breezeless forest glade[50] in the early morning with dew noiselessly

41. R. V, 66 to 74.
42. R. V, 86.
43. R. VII, 2.
44. R. VII, 42.
45. R. VII, 60.
46. R. IV, 61.
47. R. IX, 71.
48. R. X, 9.
49. R. X, 54.
50. R. XV, 66.

dripping from the trees is compared with the assembly breathlessly listening to the recitation of Lava and Kusa and shedding tears of appreciative joy. The supreme poet lavishes of his wealth even to describe the foot of the voluptuary Agnivarna[51] which he exhibited to his subjects to reassure them. The foot covered with the red lustre of tender nails resembled the lotus touched by the early morning sun.

The variegated hues of the Indian sunset and the features of the evening sky find poetic expression in many a stanza in the great epic. The radiance of Vasishta's divine cow,[52] Surabhi, who was of a red colour and who had a slightly curving mark of white hair in the forehead is compared to that of the evening sky of the hue of a tender sprout with the crescent moon. The sacred cow returning to the hermitage from grazing,[53] with the king following her and the queen in front welcoming her, resembled the rosy evening between day and night. The beauty of the queen, the power of the king and the charm of the cow are all suggested by this simile. The giant Virādha who snatched away Sita,[54] was red like the evening cloud and the dust of the brownish ground raised by the army of Bharata[55] going forward to welcome the homecoming Rama crowned with victory resembled the red evening twilight. When Kusa[56] was bathing in the Sarayu with his harem the river exhibited variegated colours as those in the sky when the sun sets amidst clouds. The poet describes also evenings of a less peaceful nature. When Rama was on his way to Ayōdhya with his bride,[57] one evening, the weather was foul. Adverse winds tore down the banner-staffs ; with a frightful halo formed round it the sun appeared like a stone fallen from a serpent killed by Garuda with the serpent's terrible body surrounding it. Hawks circled with their grey wings ; the clouds were red and moist ; and there was dust in all directions because of the high wind ; the quarters could not be looked at as women in their monthly courses ; vixen howled in the east. When Ayōdhya was deserted after Rama's death the presiding genius of the city complains to Kusā[58] that the city with her broken turrets and terraces looked like the evening sky when the sun is hidden and the clouds are scattered by high winds.

Day itself becomes a subject for poetic simile when the poet describes the joy of Dilipa[59] at the expected confinement of Sudakshina. He looked at the pregnant queen as at the sky overcast with clouds at

51. R. XIX, 8.
52. R. I, 83.
53. R. II, 20.
54. R. XII, 28.
55. R. XIII, 64.
56. R. XVI, 58.
57. R. XI, 58-61.
58. R. XVI, 11.
59. R. III, 12.

the right season when a shower of rain is expected. The king of the Prāgjyotishas[60] (Assam) could not bear the dust raised by his chariots which hid the sun and made the day gloomy and overcast as a cloudy day without any shower. But the day[61] when Aja and Indumati proceeded through the city was one of brilliant sunshine. The road was strewn with auspicious flowers and grains ; triumphal arches were radiant like the rainbow ; the sunshine was warded off by flags and buntings. When Aja rejoined Indumati[62] after routing the enemies the princess greeted the victor through her attendants as the grassy forest glade besprinkled by drops of fresh rain water hails masses of clouds by the notes of peacocks. The four sons of Dasaratha[63] won the hearts of the people as days covered with dark clouds at the end of summer.

The short, but bright June night,[64] with the early part bathed in the silvery light of the moon high up in the heavens is compared to a disappointed lady who is deceived in expecting her lover at the tryst, and consequently who is wasting and pale-faced. In the days of Dilīpa[65] there was such security of person that even if at night a drunken woman fell asleep on the high road half way to an assignation no hand was raised to molest her. Again the presiding deity of Ayōdhya[66] complains to Kusa that while in her prosperous days women with glittering and jingling anklets went at night along the streets to meet their lovers, in the days of her decay she-jackals haunted the streets howling all the time. The complexion of Tādaka[67] who came against Rama and Lakshmana is compared to the blackness of the night of the dark half of the month. In describing Sudakshina[68] during the first months of her pregnancy the poet gives a magnificent sketch of the night nearing dawn. The queen who had laid aside her ornaments because of her wasted body with her pale face resembled the night at the point of daybreak when the stars are few and the moon of little lustre. While King Atithi[69] was going out in procession the city ladies followed him with eyes beaming with love as in clear autumn nights the heavenly bodies follow the polar star.

The great poet has so skilfully woven into the fabric of his great epic brilliant sketches of the seasons that literary critics of later days have been tempted to think that no *Mahākāvya* would be complete without a description of the seasons. The most noteworthy feature of

60. R. IV, 82.
61. R. VII, 4.
62. R. VII, 69.
63. R. X, 83.
64. R. IX, 38.
65. R. VI, 75.
66. R. XVI, 12.
67. R. XI, 15.
68. R. III, 2.
69. R. XVII, 35.

Kālidāsa's sketches of the seasons is the close inter-relation portrayed between man and nature. He shows us how men's feelings and actions are excited, guided and tempered by the seasonal changes ; nay, he portrays the whole of creation as seen in the changing seasons, acting and acted upon, a fellowship of men, animals and plants growing and changing as the days roll on.

To Raghu who had established himself on the Kosala throne with even greater splendour than his predecessors ; the autumnal season (Sarad)[70] clearly discernible by lotuses came like a second goddess of royal splendour. After the heavy rains the light clouds had shrunk to insignificance and the sun's path being free his insufferable heat, as also the king's valour, penetrated to all regions. Indra put back his rainbow and Raghu took up his long bow ; clearly the king and Indra took turns to promote the people's welfare by their bows. Autumn with his umbrella of the white lotus and his *Chauri* of flowered *Kāsha* grass imitated Raghu but did not attain his regal splendour. Men looked with equal pleasure on the king's smiling face as on the clear and radiant moon. The grandeur of his renown seemed to be scattered over the rows of swans, in the constellations of stars and on the waters full of lilies. Women seated under the thick shade of sugar-canes watching the fields of *shāli* corn sang the fame of the protector which arose from his merits, recounting his deeds from his early youth. The star Canopus (Agastya) rose with great splendour and the waters became clear and calm ; but the hearts of his enemies became agitated. His bulls furious with vigour, digging up the banks of rivers, seemed to imitate the sportive grace of his prowess. His elephants poured forth rut from the seven parts of their bodies as if emulating the *saptaparna* tree with its ichor-scented flowers. The rivers had become fordable and the roads mudless ; the season seemed to persuade the king to march with his army. Similarly, the vernal season (Vasanta) with fresh flowers came to honour the mighty Dasaratha.[71] Wishing to go north the sun left the Malaya mountain brightening the early mornings by melting away the mist. Then there was the bursting of flowers and the appearance of tender foliage, then the hum of bees and the notes of the cuckoo—thus spring appeared in the thickly wooded forest sites. Bees and water-birds haunted the lakes full of lotuses charged with honey as suppliants round the treasured wealth of the king. Love was excited not merely by the Asoka flowers freshly in season but also by its tender leaves placed on the ears of damsels so pleasing to gallants. The *Kurabakas* looked like paintings by Spring on the form of the garden

70. R. IV, 14 to 23.

71. R. IX, 24 to 47.

beauty and bees buzzed round its blossoms. The wine[71a] from the mouths of pretty ladies caused the *Bakula* to bloom and its sweet scent was fragrant as their own breaths. Bees thronged the *Bakula* for its honey. The *palasa* was full of buds in every branch and the red blooms looked like nail marks on a lover. The sun had only lessened the frost; women still suffered from sore hips and chapped lips. A young mango tree in flower with its tender sprouts shaken by the southern breeze appeared bent on practising poses and gestures and thus excited the minds of even self-controlled ascetics. In the wooded groves fragrant with flowers, notes, few and far between, of the cuckoo could be heard for the first time as if they were the measured words of coy maidens. The garden creepers in flower, with bees buzzing round them, were swaying in the breeze and thus resembled graceful smiling dancers singing and keeping time to their song with their hands. Men and women drank wine, the friend of love, fragrant as the *Bakula* flower, the producer of graceful sportiveness in women. The lotuses in the domestic pleasure-ponds were in full bloom and the water birds in them were making excited and indistinct sounds; thus they resembled smiling women with loose and jingling girdles. The nights were bright with the pale moon; mist had disappeared and there was clear moonlight in which lovers sported. Women wore in their hair the soft petalled *Karnikāra* bright like the sacrificial fire fed with oblations and a gold ornament as it were to sylvan beauty. As the young woman with the *Tilaka* the forest site was adorned by the *Tilaka* tree on whose flowers dark bees had settled. The jasmine in bloom on the supporting trees maddened the minds of men; her fragrance went to their heads as wine; her white flowers amidst the tender sprouts simulated the smiles of damsels. Garments more crimson than the dawn, shoots of barley on the ears, the warblings of the cuckoo, these forces of Cupid, laid beaux at the feet of ladies. The bunches of the *Tilaka* flowers with swarms of bees around them looked like the *Jālaka* ornament worn by ladies, the bees representing the hair and the flowers the pearls. Bees followed the cloud of pollen raised by the wind from the gardens—the cloud which was as it were the banner of love and the cosmetic for the face of vernal beauty. Men and women enjoyed the swing festival.

71a. R. IX, 30 cf.

स्त्रीणांस्पर्शात्प्रियंगुर्विकसतिबकुलः सीधुगण्डूषसेकात्
पादाघातादशोकस्तिलककुरबकौ वीक्षणालिङ्गनाभ्याम् ।
मन्दारीनर्मवाक्यात्पटुमृदुहसनाच्चम्पको वक्रवाताच्चूतो
गीतान्नमेरुर्विकसतिचपुरोनर्तनात्कार्णिकारः ॥

The cuckoos seemed to have delivered this message to women from the God of Love: "Lo! fair ones! lay aside anger and strife. Youth once gone returns not." Again as a prelude to the description of Kusa's bathing in the Sarayu with his harem Kālidāsa describes the hot season (Grīshma).[72] During this season women appeared in light dresses, with few ornaments and with upper cloths adorned with pearls. When the sun came back to her from his southern course, the northern quarter shed cool tears of joy as it were by a flow of melted snow from the Himalayas. The days had become very hot and the nights had wasted away; thus they resembled an eager lover and a grieving mistress. The domestic ponds were drying up; the waters had left the mossy steps and the lotus-stalks had risen above the water; women could safely play in them since the waters were only waist deep. There were a few jasmine buds in the forests and the bee placing its foot on each and humming seemed to be counting them. Of nights the heat was terrible and the *Sirisha* flowers worn by passionate women got stuck in the perspiration. The wealthy spent the hottest part of the day in specially cooled houses, lying on stone slabs washed by sandal juice. After their bath and fumigation women wore on their lovely loose hair interwoven jasmine flowers. The charming sprout of the *arjuna* tree, yellowish by the particles of pollen, looked like a broken bit of Love's bow string. The fragrant mango-sprouts, the fresh blossomed trumpet flower and the mellow wine removed the troubles of lovers. The rays of the full and glorious moon allayed the torturing heat.

Apart from these set descriptions of the seasons many passing allusions to seasonal features are also to be found. Sunanda tells the princess Indumati that if she chose the king of Sūrasēna, during the rainy season,[73] seated on stone-slabs wetted with moisture and scented with *Shailēya*, she could watch the dance of the peacocks in the delightful dales of the Govardhana mountain. While Rama and Lakshmana were in the Dandaka forest the giant Virādha snatched away Sita from between them as drought[74] removes the rain from the midst of August and September. Rama allowed to remain behind neither the war-cry of Mēghanāda nor his bow dazzling as the bow of Indra just as the autumnal season[75] causes the thunder and the rainbow to vanish. Dasaratha took out his mighty bow as the month of Bhādrapada[76] holds up the rainbow which has for its string the streak of golden lightning.

72. R. XVI, 43 to 53.
73. R. VI, 51.
74. R. XII, 29.
75. R. XII, 79.
76. R. IX, 54.

King Nala got a son named Nabhas who was dear to the hearts of men as the month of Srāvan.[77] The house of Raghu was adorned by the four sons of Dasaratha as the celestial garden by the four seasons.[78]

Closely allied to his description of the seasons is his sketch of seasonal sports first of Kusa's bathing in the Sarayu in the hot season[79] and then of the pleasures of the voluptuary, Agnivarna. Once during *Grīshma* King Kusa wanted to sport with women in the waters of the Sarayu which had in them excited swans and floating flowers. Regal arrangements were made for the king's bath : tents were pitched on the banks and dangerous water-animals were dragged out. The swans of the Sarayu were frightened by the sounds of brushing armlets and tinkling anklets of pretty women who ran down the steps. The bathing of the ladies lent variegated colours to the water as of a sunset. The women's eyes though washed of collyrium, sparkled with passion. The women swam more because of excitement than of ability, their ear ornaments of *Sirisha* flower dropped in the waters while even their pearls got unstrung without their knowledge. The ladies had navels like whirlpools, eyebrows arched like ripples, and breasts like *chakravakas*. The charming disorder of the ladies and the sweet music pleased the king who sported among them like Indra in the heavenly Ganges with the celestial nymphs. Sporting with his harem the king was brilliant as sapphire among pearls. Decked in garlands of *Kutaja* and *Arjuna* flowers reaching down from the shoulders and with the body covered with *Kadamba* pollen King Agnivarna[80] sported with his ladies during the rains on artificial hillocks which had excited peacocks in them. When the clouds rumbled his angry mistresses embraced him without any persuasion. He enjoyed the company of women in the bright autumnal moonlight under an awning in the terrace. To the voluptuary the sandy banks of the Sarayu with the swans on it looked like the hips of a woman encircled with a girdle. During the winter women attracted him by their rustling garments scented with *agaru* and *dhupa* and showing the golden waistbands underneath. Through the long and windless nights of *Sisira* the king enjoyed uninterrupted pleasures by lamplight. In spring the flame of love was fanned by the warm southern breezes loaded with the scent of mango-blossoms. The king enjoyed the pleasures of the swing and the embraces of the ladies who were anointed with sandal and adorned with pearls and gold. With his ladies he drank wine mixed with mango-sprouts and the red *Pātala* flowers.

77. R. XVIII, 6.
78. R. X, 80.
79. R. XVI, 54 to 71.
80. R. XIX, 37 to 46.

The sun, the moon, the ocean, the elephant and the lotus are favourite subjects for poetic comparison for Sanskrit poets. They have a recognised symbolic value and well-understood attributes. Kālidāsa uses for his poetic purposes this symbolic and euphuistic aspect of nature but always adds to it a delicate power of suggestion and an astounding wealth of poetic imagery.

The sun is the most outstanding of nature's works in the tropical sky. It is natural that he should be regarded as the sovereign monarch with a thousand arms, powerful beyond compare, the dealer of life and death to all creation. He occupies a commanding place in the Vedic pantheon and his names are honeycombed with traditional and mythical associations. In almost every one of these aspects the sun appears in Kālidāsa's poetry. Dilīpa[81] taxed the people only for their benefit; the sun takes up vapour only to return it a hundredfold. The sun[82] with his horses fleeter than the wind traverses the four quarters extensive as ocean: so does Raghu with his intelligence, the fourfold learning. The quickness of Raghu's intelligence, its subordination to one dominant beneficent purpose, and the vastness of the field as well as the ease of mastery are all suggested here. Dilīpa[83] with Raghu was powerful as the autumnal sun. On receiving the kingdom from his father Raghu[84] shone more brightly as does the fire by the radiance deposited in it by the sun at the close of day. As the moon gets the name *Candra* because he delights men, the sun the name *tapana*[85] by his extreme heat so the king was deservedly a *rāja* since he pleased his subjects. His irresistible power extended in all directions as the unendurable rays of the autumnal sun.[85] Even the heat of the sun diminishes when he reaches the Pāndya kingdom[86]; but the Pāndya could not endure Raghu's prowess. The sun[87] started on his northerly course wishing to suck up vapour with his rays; so did King Raghu turn north wishing to overthrow the northern kings with his arrows. Raghu[88] tells the sage Kautsa that he derived all his knowledge from his preceptor as the world derives all activity from the sun. What the sun is to the living world that the good preceptor is to the pupil; he quickens, vivifies and sets in motion the powers latent in him. Replying to the king's words of welcome Kautsa[89] tells Raghu that they were prosperous in all parts of his kingdom: how could there be evil when Raghu was the

81. R. I, 18.
82. R. III, 30.
83. R. III, 37.
84. R. IV, 12, cf. 'अग्निवा आदित्यः सायंप्रविशति'
85. R. IV, 15.
86. R. IV, 49.
87. R. IV, 66.
88. R. V, 4.
89. R. V, 15.

protector? While the sun shines how can pitch darkness hide the visions of men? Raghu quickly got a son from the sage's blessing as the animate world gets light from the brightly shining sun.[90] In his description of the King of Avanti Kālidāsa refers to the Puranic story which recounts how Tvashtṛ, the Vulcan of the Indian pantheon, on the request of his daughter *Samgnā,* who was unable to endure the brightness of her husband, the sun, mounted the sun on his grinding wheel and trimmed off a part of his bright disc. Sunanda describes the king to Indumati, thus: "This long-armed,[91] broad-chested and slender-waisted lord of Avanti shines like the sun ground down with great effort by Tvashtṛ who had mounted him on his grinding wheel." The princess[92] did not fix her affections on the King of Ujjain who gladdened his friends and weakened his foes by his valour, as the lily loves not the sun who dries up the mud and causes the lotus to bloom. Having spent three nights with Aja on the route the King of Kundina[93] parted from him as the moon recedes from the sun at the end of the conjunction. During the battle between Aja and his enemies the sun[94] appeared as if through a pile of silken cloths because of the dust, raised by the horses, thickened by the wheels of chariots and spread out by the flapping of elephants' ears. With the former king intent on a life of spiritual tranquillity and the new king just entering on his royal career the family of Raghu[95] resembled the sky with the moon almost gone down and the sun just come above the horizon. The radiance of Dasaratha[96] whose fame extended to all the ten quarters was like that of the sun with his ten-hundred rays. Having freed himself from the debts due to sages, gods and ancestors by the recital of the Vedas, by the performance of sacrifices and by the begetting of a son King Aja shone brightly like the sun[97] freed from the misty halo. Similarly Dasaratha resembled the sun[98] by his radiance. Going in front of Indra with a single chariot, the valiant Dasaratha armed with his bow laid the clouds of dust obscuring the sun[99] by the blood of the demons. The Gods harassed by Ravana

90. R. V, 35.

91. R. VI, 32. Note the epithets उदग्रबाहु, and तनुवृत्तमध्यः which are applicable to the sun as well as the king.

92. R. VI, 36.

93. R. VII, 33.

94. R. VII, 39.

95. R. VIII, 15. Note the epithets प्रशमस्थित and अभ्युद्यत which emphasise the similarity between the kings and the sun and moon.

96. R. VIII, 29.

97. R. VIII, 30.

98. R. IX, 6.

99. R. IX, 23.

went to Vishnu as travellers oppressed by summer heat[100] resort to a shady tree. "Thy deeds transcend all praise, even thought and expression, as the treasures of the ocean or the brilliance of the sun,"[101] say the Devas to Vishnu. Rama and Lakshmana followed the path of the highly powerful sage Viswamitra as the months of Chaitra and Vaisākha follow the bright sun's course.[102] Rama received a missile from the sage as the sun-stone (the double-convex lens) receives from the sun[103] the light that consumes faggots. Rama and Lakshmana alternately guarded the sage as the sun[104] and the moon alternately rising and setting protect the world from deep darkness. Dasaratha started towards Mithila with a huge host overcasting the brightness of the sun[105] by the dust raised by his army. Parasurama wearing the paternal sacred thread and the maternal strong bow looked like the sun[106] in conjunction with the moon or the sandal tree with the serpent. Rama and Parasurama standing facing each other resembled the sun[107] and the moon facing each other in the evening on a full moon day. Like the sun[108] travelling from the northern solistice to the southern, Rama went southwards from Ayōdhya and the subjects felt his absence more and more and were in tearful gloom when he was away. When Ravana's heads were cut off the ten necks of his falling body appeared like the images of the morning sun[109] reflected in the ripples of water. Describing the Dandaka forest to Sita, Rama points out the sage Sutikshna[110] who performs penance under the scorching rays of the seven-horsed sun, who nods at Rama in recognition and who, after the brief interruption caused by the Pushpaka, resumes his gaze on the thousand-rayed one. Satrughna, best among the resplendent, whose path was indicated to him by the *munis* who went in front of his chariot, shone like the sun[111] preceded by the Vālakhilyas, the sixty thousand pigmy sages born of Samnāti, the wife of Kratu. The Sage Vālmiki went up to the glorious Rama who was accompanied by Sita and her two sons; thus accompa-

100. R. X, 5.
101. R. X, 30.
102. R. XI, 7.
103. R. XI, 21.
104. R. XI, 24.
105. R. XI, 51.
106. R. XI, 64.
107. R. XI, 82.
108. R. XII, 25.
109. R. XII, 100.
110. R. XIII, 41 and 44.
111. R. XV, 10. The reference is to Bhāgavata, Bk. XII, Chap. 11.

nied Rama resembled the radiant sun[112] worshipped by the sage with the Vedic hymn having correct accent and words. The handsome Atithi purified the families of his father and mother as the brilliant sun[113] purifies the southern and the northern courses. The image of the gaily decked king shone in the golden mirror like that of the *Kalpataru* on Mount Meru in the sun[114] just rising on the horizon. The rays of the sun[115] burst forth some time after his rise; but Atithi rose up with all his qualities at once. Nothing remained unnoticed by the king who had thrown out rays of light in the form of spies over the whole of his territory just as everything is seen by the sun[116] free of all clouds. The king made all his subjects faithful to his rule by destroying the darkness of ignorance and evil, by imparting a correct knowledge of material things and by removing calamity by his very sight; so is the sun[117] auspicious to the sight and gives men a true perception of things by dispelling darkness. The moon's rays cannot enter the lotus; nor can sunlight penetrate the lily; but the King's virtues were appreciated even by his enemies. Vyushitāsva[118] who had quartered his cavalry on the beach had a lustre like that of the sun.

(To be continued.)

112. XV, 76. The vedic hymn is Sāvitri.
113. R. XVII, 2.
114. R. XVII, 26. The image is very suggestive and beautiful; but complex and unfamiliar.
115. R. XVII, 34.
116. R. XVII, 48.
117. R. XVII, 74 and 75.
118. R. XVIII, 23.

On the Notion of Time

By

P. S. Naidu

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(Continued from page 181, Vol. III, No. 2.)

Time is not to be identified with movement; nor is it to be identified any more with number. It is undoubtedly true that Time is the 'number of motion,' but its nature is not exhausted by the numerable aspect of movement. Hence, in the absence of a perceiving mind the application of arithmetic to movement would, no doubt, be impossible; but motion would exist and Time which is not bound down to its numerable aspect would certainly exist.

Aristotle's concept of 'nowness' throws the puzzling problem into greater relief. That a period of Time has elapsed is realised by us when we distinguish two 'nows' and an interval between them, just as we realise that motion has taken place by distinguishing the two points in space from one of which a body has moved to the other. A 'now' has been now here and has moved back into a 'then'; a fresh 'now' has taken its place. This 'now' is the end of past time, and the beginning of present Time. Yet we are told that these 'nows' are no more parts of Time than points are parts of a line. The continuous nature of Time cannot be adequately defined by a succession of 'nows.' When we compare Aristotle's definition of the 'now' with Plato's discussion of the 'moment,' we realise how these great systematic thinkers grapple in vain, in the absence of proper aid from Psychology, with the tantalising concept of the 'specious present.'

Wolfson, in his monumental edition of the Critique of Aristotle, points out that some of the difficulties in the conception of Time could be overcome if Crescas' definition be accepted. 'According to this new definition, Time is not motion but duration. Unlike motion, duration does not depend upon external objects for its existence, and it does not arise in our mind out of the motion of things outside ourselves. It is rather the continuity and flow of the activity of the thinking mind. . . . . Given therefore a thinking mind, even were there no external reality, there would be such duration. ....Unlike

Aristotle, then this definition maintains that it is not Time that measures motion but it is rather motion that measures Time.'[1]

In a metaphysical system wherein the process of change—the actualisation of the potential—plays a preëminent part, we should expect Time to occupy the central place. But such an expectation in the case of Aristotle is fore-doomed to disappointment on account of two reasons. In the first place the 'Entelechy', towards the realisation of which the 'potentiality' is striving, is prior to the possible, and in the second place God who is the 'limit, the Being who existed to the nth power, towards which the universe aspired and mounted step by step,' is Himself immovable and unchanging and so transcends Time. Into the essence of things whose limits are thus definitely pre-determined Time cannot possibly enter.

The Stoics and the Epicureans

The story of the development of the concept of Time, and as for that matter, of any physical or metaphysical concept, in the post-Aristotelian period prior to the birth of Neo-Platonism is soon told, because it is a story of deterioration.

The *Stoic* treatment of nature is refreshingly original and independent. In their dynamical theory of nature *force* occupies a more important place than *matter*. The only type of cause which they recognise is the efficient cause. Such a promising start should have yielded a fruitful concept of Time, but the Stoics made no attempt to develop the idea. 'Time also, is by them set down as immaterial; and yet to the conception of Time a meaning as concrete as possible is assigned, in order that Time may have a real value. Zeno defines Time as the extension of motion; Chryssipus defines it, more definitely, as the extension of the motion of the world. The Stoics affirm the infinite divisibility of Time and space, but do not appear to have instituted any deep researches into this point.'[2]

To the Epicureans Time is simply an accident of motion. A consideration of their view of the universe and of change within the universe will give us the clue for understanding their concept of Time. Epicurus in his physical speculations says 'the universal whole always was such as it now is, and always will be such. For there is nothing into which it can change; for there is nothing beyond this universal

1. Crescas' Critique of Aristotle (edited by Wolfson), p. 96.
2. Zeller; The Stoics, Epicureans and Sceptics, p. 186.

whole which can penetrate into it, and produce change in it . . . .'[3] Further on he says, 'the atoms are in a continual state of motion.. All the atoms are necessarily animated by the same rapidity .... At the same time, an atom has not, in any moment perceptible to the intelligence, a continued movement in the same direction; but rather a series of oscillating movements from which there results, in the last analysis, a continued movement perceptible to the senses.'[4]

The atoms, no doubt, partake of motion and in consequence are in Time, but the change resulting from their movement is not ultimate since it does not affect the whole. Time which is an aspect of motion is merely an accident. Lucretius also, in his poem *De Rerum Natura,* expounds the same doctrine of Time.

Resumé

We have now reached the close of the first great era in European speculation. In this period practically every aspect of the problem of Time is brought to the fore and discussed, but not worked out to a finish. That Time is indissolubly linked with change is fully realised by every one in the long line of thinkers from Heracleitus down to Aristotle, but when they come to the actual definition of the relationship between Time and change they seem to be on very uncertain ground. Even the best of their definitions, namely, that of Aristotle, is but a sorry approximation to the brilliant formula of Bergson. The reason for the defect is that for all ancient thinkers changelessness is the highest ideal, and so according to them absolute perfection is without Time. Yet they seem to be reluctant to throw Time overboard so summarily. Plato makes a valiant attempt to retain Time (in the form of Eternity) within his world of ideal existences, but any such attempt is bound to fail so long as the highest ideal is barren, static and lifeless.

The ancients, Zeno the Eleatic and Aristotle in particular, probe deep into the subtleties of the concepts of infinity and infinite divisibility of Time. The contradictions involved in them are brought to light. But an important point seems to have been overlooked. We may readily agree with Aristotle that any given interval of Time is infinitely divisible, but we should not lose sight of the fact that it is a finite quantity. The sum of a convergent series constituting of an infinite number of terms is a finite quantity. This simple mathemati-

3. Bakewell: Source Book of Ancient Philosophy, p. 293.
4. Ibid, p. 293-4.

cal truth forces on our attention the distinction between the percept and concept, between the idea logical and the idea psychological. This distinction as applied to Time is mentioned by Aristotle, but is not developed by him. In the same manner there is an incomplete discussion of the nature of the 'specious present,' called the 'moment' by Plato and the 'now' by Aristotle. The abstruse problem of duration of consciousness also seems to have been raised by the latter but without any fruitful results. In short, Ancient Philosophy projects brilliant flashes of intermittent light on the problem of Time without illuminating any aspect of it clearly.

Plotinus

The lonely star of Plotinus rising late in the firmament of Ancient Philosophy and soaring high above the other luminaries radiates strange light of uncommon brilliance; light which illumines without dazzling. Plotinian metaphysics is unmistakably *sui generis* and should be treated as such. On the ground that a period of five centuries separates him from the last of the Ancients, and that his thought has certain affiliations with Christian mysticism, Plotinus is sometimes clubbed with Mediaeval thinkers. But his system is as near to Mediaeval mysticism as it is to Platonic Idealism. We, therefore, treat him as constituting a class by himself.

The problem of Time is discussed by Plotinus in the Enneads (III, 7). He surveys the views of all his predecessors and says, 'it is enough for us to select the wisest of their opinions and try to understand it.' The Pythagorean, Platonic, Aristotelian, Stoic and Epicurean views are passed in review and finally the second named doctrine is chosen as being the most satisfactory. On the basis of the Platonic theory of Time, Plotinus proceeds to construct his own. The most striking portion of the Plotinian definition of Time is the naturalness upheld in it. He says that 'Time simply had to be.' No doubt philosophers have been sorely troubled by the contradictions involved in it; but these contradictions 'which become apparent when the intellect treats them as ultimate realities are one of the means by which the Soul is forced upward to the intuitive perception of the Spiritual life.'[5]

'For Time may be said to be either (*a*) motion, or (*b*) that which is moved, or (*c*) something pertaining to motion .... Of those, however, who say that Time is motion, some indeed assert that it is

5. Dean Inge: Philosophy of Plotinus, Vol. 1, p. 172.

every motion; but others, that it is the motion of the Universe. But those who say it is that which is moved, assert it to be the sphere of the Universe. But those who say that it is something pertaining to motion consider it either as extension of motion, or as its measure, or as some consequence of motion in general or of regulated motion.' (Enneads III, 7, 6).

Plotinus thus sets his face definitely against all views of Time which identify it, either in part or whole, with physical movement and for the first time links it with the activity of the Universal Soul. Time is the result of the desire of the restless soul to manifest itself. 'Time, still non-existent, reposed in the bosom of Reality, until Nature, wishing to become its own mistress and to enter into possession of itself, and to enlarge the sphere of its activities, put itself, and Time together with itself, into motion.' (Enneads III, 7, 11).

Time thus arises through the constant activity of the World-Soul to translate what it sees in the external world into another form. 'Time is the activity of an eternal soul, exercised in creation.'

Though Plotinus protests against the distinction between the phenomenal and the noumenal in regard to Time, he yet speaks of 'every distinct idea Yonder becoming a finite purpose Here.' 'Time is the *form of willed change.*'

The most important point in the discussion of Time by Plotinus is the inclusion of the idea of teleology in it. Evidently he cannot conceive of change or movement without an end. He asserts that potentiality derives its meaning only when we view it in the light of an actuality into which the potentiality should ultimately develop. Although he identifies Time with duration, yet his thought fails to rise to the Level of Bergson's *La Duree.*

War in Ancient India

By

V. R. Ramachandra Dikshitar

[Mr. V. R. Ramachandra Dikshitar, M.A., Lecturer in Indian History, University of Madras, delivered a course of five special lectures under the auspices of the Annamalai University, at the Oriental Hall, Annamalainagar, on the 16th, 17th, and 18th November 1934. The following is a summary of the lectures. Editor, A. U. J.]

LECTURE I.

The Psychological Background of War.

The history of India is largely a history of the Hindu culture and progress and it begins at the third millennium B.C. according to the tentative conclusions arrived at by an intensive study of the finds in the Indus Valley.

War is an institution as much of the ancient aboriginal tribe as of the later civilised community. Hence the existence of it can be traced to the ages before the compilation of the Ṛg Veda Saṁhitā. The Veda envisages a period of prolonged wars with the tribes which went by the name of Dasyus. The Purāṇas, epics and the Tamil classics refer to wars as having been waged. Coming to the historical times we hear of the wars waged by the Nandas, Mauryas, Andhras, and the Guptas.

The ancient wars, as the modern ones, can be accounted for by the psychological impulses that have actuated the contending parties in a war. In ancient times of which barbarism and savagery were the main characteristics we find that bellicosity was the order of the day and the only object of worship of the primitive tribes and communities was Bellona or the Goddess of War. Among the Indo-Aryans who appear to have been lovers of peace in preference to war on account of its horrors, the necessity they felt for finding a home to live in and the opposition they had to face from the people who had already settled on the soil, led to wars being waged. According to the evidence of the Aitareya Brāhmaṇa war begat King among the Devas and if we are to identify them with the Indo-Aryans then we have the assurance that the institution of war among them

preceded that of kingship itself. When the society came to be well settled on the soil and the institution of war came to be recognised to be a necessary evil there arose a class of warriors whose occupations were hereditary in character. These came to be called the Kṣatriyas. Their sole duty was the waging of wars and the protection of the society. The necessary education, drill, and discipline for the preservation and continuation of the military spirit were confined to this community. As the guardians of the peace of the country, the Kṣatriyas came to occupy a high social rank. Further the mental atmosphere in which they lived and moved made them ever be in a state of war preparedness. This attitude of the mind was not entirely the concomitant result of a spirit of adventure but wholly a result of the realisation of the fact that by war, the warrior and hero were doing a piece of service which tended towards common good and which was consequently acceptable to the common will. The Kṣatriyas believed honestly that peace was a negation of all noble service and noble energy. It was this psychological barrenness of peace that led to frequent wars in Ancient India. During times of peace individual warriors engaged themselves in a number of adventurous campaigns. The motives for them were various and chief among them were the capture of women, lifting of cattle, and seizure of wealth. The warrior was always a robber and a pillager. This life was the knight's support and cattle-lifting provided the needed gain. The Eiynar who are mentioned in the Tamil Classics, for example, were professional cattle-lifters.

The Gandharva and Svayamvara marriages appear to have been the survivals of the earlier and much simpler forms which consisted of knights meeting with girls openly or secretly and carrying them away with or without the knowledge of the parents of such girls. Such capture of girls led to wars. Bhīṣma, for instance, had to fight for the hands of three girls while Arjuna had to fight for the hand of Subhadrā.

The Kṣatriyas were pugnacious by nature and this pugnacity had its share in precipitating the outbreak of wars. The ancient Hindu society encouraged such pugnacity under a system of civilised legality. The Mātsya Nyāya worked with wonderful effect in India. The problem of defence also led to the outbreak of wars in ancient India. Every state, big or small, cultivated its own defences to prevent aggressive encroachments by the other states. The Arthaśāstra of Kauṭalya envisages a circle of states always at war with each other. Hence the frontiers of the empires were strengthened. Janasthāna,

the northern frontier of Rāvaṇa's Empire was strengthened by the Rākṣasa king. A son of Bharata was appointed as the governor of Takṣaśīla, the frontier province of the empire of Rāma. Gāndhara, the present Kandhahar, formed the frontier of the empire of the Pāṇḍus and Mauryas.

Another cause of war was the fear impulse. The subordinate ruler was always afraid of the imperial sovereign, and the emperor was always afraid of the possible revolt of the subordinate. Hence emperors and subordinates alike were always in a state of mutual suspicion. The spirit of jealousy among the princes led at times to the outbreak of wars. The jealousy entertained by the Kauravas against the Pāṇḍavas which led to the great battle of Kurukṣetra is an instance in point.

Jealousy brought in its train imperial notions of overlordship and love of glory. The ancient Indian king brought under his sway his neighbouring princes and proclaimed himself the sole ruler of the earth. It was this love of glory that made each of the respective rulers of the three Tamil kingdoms of South India carry his sword as far north as the Himalayas and implant on its lofty heights his respective crest.

It was the same love of glory that prompted our ancient emperors to perform big sacrifices like the Aśvamedha after defeating 100 kings which would raise them to Indrahood. After the performance of these the king took the title of Sārvabhauma or Ekarāṭ.

LECTURE II.

The Warrior's Code.

Hindu military science recognises two kinds of warfare—the Dharma Yuddha and the Kūṭa Yuddha, otherwise known as the Prakāśa Yuddha and the Mantra Yuddha. According to the former certain ethical principles and standards were followed. For the waging of war without regard to moral standards would degrade the institution of war to mere animal ferocity.

Before the commencement of war an ambassador was sent to the enemy with an ultimatum that he should either fight or submit. War was then resorted to only after the instruments of diplomacy had failed to effect the desired end. Prayers were offered to God for a week before the army started for war, and on the night before the battle the king used to sleep in his chariot with his weapons by his

side. The following were some of the rules observed in the battlefield. A warrior fought with only one warrior and when he became disabled the fight was given up. The weak or wounded man was not to be killed or one who had no son. A king was to fight only with a king. The aged, children, women, the retreating, or those who held straw on their lips as a sign of unconditional surrender, were not to be killed. Temples and other public institutions were left unmolested. Prisoners of war were to be accorded generous treatment. Usually the defeated ruler was reinstated in his position. The internal system of administration and other social institutions were left unmolested. The wounded were carefully attended to. In the army there were many physicians to attend to the wounded. Battle was stopped during the night. The announcement of victory was followed by the offer of worship in temples. According to Bṛhaspati one-sixth of the spoils went to the king and the rest to his friends and allies. In the fight itself cruel and poisonous weapons were not used.

In the Kūṭa Yuddha recourse was had to crafty methods, intrigues, charms and spells. The baser methods of diplomacy like māyā and Indrajāla underlay the practice of Kūṭa Yuddha.

LECTURE III.

Army and Army Organisation

Regular and proper organisation is the life and soul of an army. Hindu India possessed the classical four-fold forces of chariots, elephants, horsemen and infantry collectively known as the Caturaṅgabala. To these divisions, the power of counsel and kośa or the power of treasury were later on added. As regards the chariots they appear to have been under a special officer who was called the Rathādhyakṣa. The value of the chariot lay in the protection it gave to the army in general. Usually besides the charioteer there were two fighting men in the chariot. The elephants were also under the supervision of a special officer. The war elephant generally marched in front of the army clearing the way of weeds and shrubs. The cavalry was managed by a special department. In the selection of the horses, their age, strength and size were taken into account. Similarly the infantry as a separate army department was under the charge of a special officer of the state. They carried bows in their hands which they used in war. Commissariat and admiralty formed two other divisions of the army. Candragupta's army was controlled by a body consisting of six divisions with five members in each. Evidence is not lacking to show that fleets were maintained in the

interests of the state and wars were waged on the seas. For the army the members of all the castes were recruited. The army was divided into many units and were known as patti, senāmukha, gulma, gaṇa, vāhini, pratana, camu, anīkini, and akṣauhini.

In war as in all other important state affairs the ancient Hindu king sought and followed the advice of his ministers. Rāvaṇa had his council which he very often consulted in the course of his wars. The Council consisted of wise and loyal men versed in military science and grown grey in experience. The council of ministers was to be consulted whenever envoys were sent to foreign states. The king generally followed the advice of his councillors and it was more or less obligatory on his part to do so. Such councils were summoned and controlled even in the battle-fields. For instance, when Balarāma and Kṛṣṇa were in the mountains of Gomanta Jarāsandha who arrived at its foot, held a council to devise means how to encounter them.

The special importance of finance for war was recognised in ancient India. Among the important heads of military expenditure in ancient India were the salaries of soldiers, military officers and diplomatic agents, the construction and repair of fortifications and the purchase of military requisites. Further, considerable sums of money were spent as bribes for securing information and fomenting troubles in the enemy-territory. We see that the military expenditure was a little over 50 per cent of the total expenditure of the state. The Arthaśāstra insists on the regular payment of soldiers. Full pay was to be given to those who had completed the practical course of training and half-pay to apprentices. It appears that the pay of the military officers and soldiers was dependent on the economic condition of the times. In the face of sudden attacks and in the absence of the necessary funds in the treasury, a king could encroach upon the private property of his wealthy subjects by levying more taxes on them. Voluntary contributions were raised at times of grave danger to the state but these were returned later.

The arsenal consisted of weapons of war. Registers were kept in which were entered details as to the shape, size, value, number and name of each weapon manufactured and distributed.

There appears to have been a separate foreign office in the post-epic age and the officer-in-charge of this department was known as Sandhivigraha or Mahāsandhivigraha.

The army was managed by officers of different grades. One of them was the senāpati who was generally chosen on the eve of the

battle. But in the later period it is doubtful if he occupied the same position and discharged the same functions. Another officer was the nāyaka for whom Kauṭalya recommends 12,000 paṇas as pay. Another was the Kumāra who appears to have been subordinate to the senāpati in office. The Saciva was the minister of peace and war. Among other officers mention may be made of the Pattipāla, gaulmika, Śatānīka, Anuśātika, Sahasrānīka and a few others.

LECTURE IV.

Kinds and Methods of Warfare

Wars in ancient India can be divided under three heads—land wars, naval wars and aerial wars. The land fights included generally wars on plain country, forests and hill regions. They were fought away from villages and cities. March was of two kinds, slow and quick or forced. It was undertaken after the roads had all been previously been examined and had been cleared of thorns and ferns. Rivers and canals on the way were forded either with the help of the elephants or by boats and canoes. The vanguard forces marched first followed by the king and the main body of the army. The less brave were in the rear. The flanks of the army were protected by horsemen, elephants and charioteers.

The camp was made on the plain country. It was generally quadrangular in shape, furnished with four gates, six roads and nine divisions, and surrounded by ditches for purposes of defence in times of danger. The camp was a miniature town and a self-sufficient unit.

The site chosen for battle was generally a plain. In the front the flower of the army were stationed. Behind them were the archers, the horsemen, and elephant-men in order. The king himself did not take active part in the actual operations of the field. Entangling the enemy in an ambuscade was at times preferred.

During actual operations the armies were arrayed according to certain arrays known as vyūhas in Sanskrit Literature. In the great war at Kurukṣetra the armies were arrayed according to the vyūhas. A particular vyūha was adopted at a particular time and this was influenced by diplomatic considerations of a strategical and tactical character. But in the Kūṭayuddha a different type of tactics was followed. Enemies were duped by unrighteous acts. False shouts of victory were made.

Siege warfare was an important aspect of land fights in ancient India. Natural fortifications were taken advantage of and in their

absence artificial fortifications were made. The fortress was a town in itself. All the amenities of life could be had there and it was surrounded by deep ditches, moats and high walls with towers over them and gates piercing them. Five methods appear to have been followed in capturing a fort. They are intrigue, pretending to retreat, winning over the people, actual siege, and taking by assault. First the enemy was tried to be brought down by bribing his officers. Sieges could be begun only if every circumstance was in favour of the invader and against the enemy.

Naval warfare was also in vogue in ancient India. There is sufficient evidence to show that there was a good navy in India from very ancient times—even in the days of Ṛg Veda. Sahadeva is said to have crossed the seas and brought many islands under his sway. Sugrīva speaks of Sumatra, Java and even the Red Sea when he sent his monkey hosts in search of Sītā. The Andhras had a good fleet. There seems to have been connection between Kalinga and Ceylon from very early times. Likewise in South India, the Pallavas, the Ceras, the Pāṇḍyas, and the Coḷas had fleets of their own. The overseas dominions of Coḷas are too well-known. The Ceras are said to have defeated the Yavanas on the Sea. There seems to have been a separate department of admiralty in the charge of a Superintendent. His jurisdiction included vessels used for commercial purposes also. The nautical enterprises were not uncommon in Ancient India.

There is also evidence of aerial warfare in Ancient India. The flying machines were of different shapes like those of elephant, horses, monkeys, different kinds of birds, chariots and other cars. They were made of light wood. Lt.-Colonel James Churchwood of Mount Vernon, New York, announced sometime back that the astonishing contents of 125 tablets discovered in India showed that the armies of 10,000 B.C. in India had flying machines of great simplicity that would carry scores of men.

LECTURE V.

Diplomacy and Diplomatic Agents

In ancient India wars were tried to be avoided by a well calculated policy which we now term as diplomacy. Sāma, dāna, bheda, daṇḍa were the four cardinal points of the ancient Indian diplomatic system. Diplomacy was followed from very early times in India. In the course of a discourse which the diplomat Kaṇika gives to Dhṛtarāṣṭra he stresses the importance of diplomacy by the acts of concilia-

tion, the expenditure of money or by producing disunion among his allies by the employment of every means in one's power. Nārada and Bharadvāja also have their views on the means of gaining a victory over the enemy by diplomacy.

According to the Maṇḍala theory, a maṇḍala consists of twelve kings, the invader, immediate enemy, invader's ally, enemy's ally, invader's ally's ally, enemy's ally's ally, rear enemy, rear friend, ally of rear enemy, ally of a rear ally. Behind them are the Madhyama (medium) and Udāsīna (super). The last two are states of higher grades of strength perhaps to meet emergencies of reference to such powers. The conception of the Maṇḍala is essentially dynamic. The kings residing in the successive concentric circles are not neutrals. Each of these possesses the power of deliberation, lordship, and activity with their respective adjuncts of intellect, treasury and heroic valour. Besides each of them had the five veritable elements of sovereignty, the minister, the country, the fort, the treasury and the army.

Generally, so far as foreign policy was concerned, six methods were followed by the kings in ancient India. They are Sandhi (peace), Vigraha (war), Āsana (maintaining a post against an enemy), Yāna (preparedness for attack), Samśraya (friendship), and Dvaidhībhāva (double dealing or duplicity). The conditions that determined their action were daiva (providential) and mānuṣa (human). The invader was to set out for conquest when he found his enemy weak and himself prosperous. He was also to watch the movement of the madhyama and udāsīna kings. Alliances were to be sought with good kings and were to be kept to the very end. Peace was to be made with equals and superior powers and hence indiscriminate alliances were deprecated.

Vigraha was a diplomatic contest and was a means to an end, i.e., to avoid regular wars. To the four means of sāma, dāna, bheda and daṇḍa were added in the later days three more—upekṣa, māyā and indrajāla. The conquering king was asked to observe this policy of conciliation by the promise of villages, forests and of sheep and cattle. It was used to bring the weaker kings under control. If conciliation did not give the desired effect the method of enticing the enemy by gifts was adopted. The policy of bheda or dissension was pursued in the case of the unrighteous. Recourse was had to the policy of daṇḍa which was not actual punishment but threat of punishment if the three means had failed to give the desired effect. Upekṣa or the policy of indifference was followed by the weaker kings in their

relations with superior powers. Māyā was a baser kind of diplomacy by which the ruler of a kingdom discarded the straight path and tried to hoodwink the enemy by intrigues. Indrajālā was a strategem to ensnare the enemy. Thus these seven expedients were all based on the six-fold policy.

The diplomatic agents were ambassadors and spies. The institution of ambassadors is not a peculiar feature of modern warfare. These officers occupied a very honoured place as befitted their status and functions. They were persons skilled in getting information about the strength and position of enemy's force. They belonged to a noble family and were intelligent, honest, industrious, versed in all sciences and they possessed the faculty of reading other minds. They were also expected to have an attractive personality. Kauṭalya distinguishes between three classes of ambassadors, but none of them was analogous to the modern consuls of foreign states. There were salutory regulations touching the treatment that was to be meted out to an envoy. Delivering the message entrusted to him, respecting treaties, issuing ultimatums, getting allies, resorting to intrigue whenever necessary, sowing dissensions among the enemies' friends, carrying away by stealth or otherwise the enemy's secret force, relatives, and wealth, and doing the work of a spy occasionally were the functions of a true ambassador.

Important as was the ambassadorial system, espionage was equally important. From the point of view of diplomacy the institution of spies had a greater utility as the king invariably took action on the report of the spies. There was a regular secret service department. They were as it were the king's eyes and watched the movements of the enemies. In theory secret diplomacy was denounced but was still put into practice.

In concluding the course of lectures, the lecturer said: "To-day there is a genuine attempt to abolish war and eliminate force altogether from world politics. But war is a law of human existence. It cannot be eradicated, but it may be ennobled. Let us therefore prefer conciliation to coercion and let us aim more at peace and less at war. Let us aim at the annihilation of international anarchy and the substitution of world peace. Let us resolve on the renunciation of war and make the ties of peace too strong to break. Let us think and act not in the terms of nationalism but in terms of internationalism."

A synthesis of ψ-meconine-carboxylic acid and new syntheses of 2 : 3-methylenedioxy-11 : 12-dimethoxy-oxyprotoberberine, and 2 : 3 : 11 : 12 tetramethoxy-oxy-protoberberine.

By

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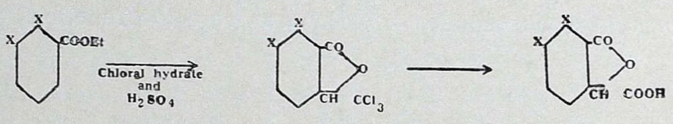
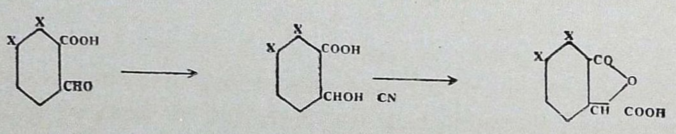
There are very few good methods available for the synthesis of substituted phthalide-carboxylic acids. The method which has been most widely used is the one due to Fritsch (Annalen., 1897, *296*, 354 ; 1898, *301*, 358. Compare also Alimchandani and Meldrum J., 1920, *117*, 968 ; Herzig, Annalen., 1921, *421*, 289 ; Alimchandani J., 1924, *125*, 539 ; Graves and Adams, J. Amer. Chem. Soc., 1924, *45*, 2453 ; Chakravarti and Perkin J., 1929, 200 ; Charlesworth and Robinson, J., 1934, 1532). The method consists in condensing a substituted benzoic acid (or ester) with chloral hydrate and then hydrolysing the product :—



The chief drawback of this-otherwise excellent-method is that it cannot be always applied, and that good yields are obtained *only when* there is a para activating group (*e.g.*, p-methoxy group, etc.) present in the starting acid.

A more recent method is to condense a substituted O-phthalaldehydic acid with hydrogen cyanide (or KCN) and then to hydrolyse the product (Compare Freundler, Bull, Soc. Chim., 1914, (iv), 15, 465; Perkin, Ray and Robinson, J., 1925, *127*, 740) :—

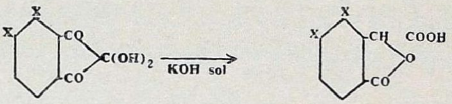


It has not been found possible to use this method extensively as the starting substances—the substituted O-aldehydo carboxylic acids—

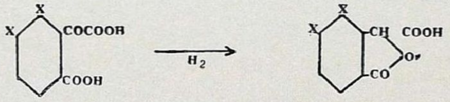
could not be readily obtained in many cases (compare Perkin and Trikojus, J., 1926, 2925 ; Chakravarti and Perkin, loc. cit.). Now that a simple general method of synthesising the substituted O-aldehydo-carboxylic acids has been recently discovered (Chakravarti and Swaminathan, J. Indian Chem. Soc., 1934, 11, 715) it should be possible to utilise Robinson-Freundler method of preparing phthalide-carboxylic acids more extensively.

There are three other reactions which could, probably, be used as general methods for synthesising the substituted phthalide-carboxylic acids. The possibilities of these schemes, which are outlined below :—

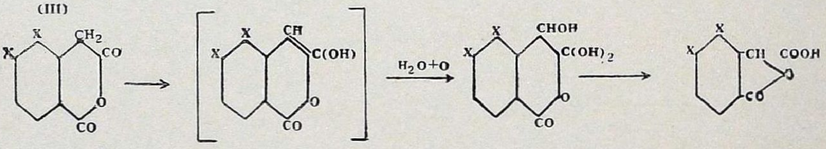
(I)



(II)

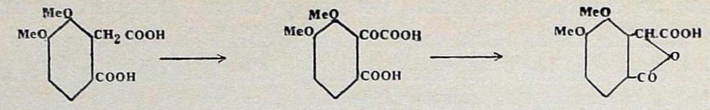


(III)

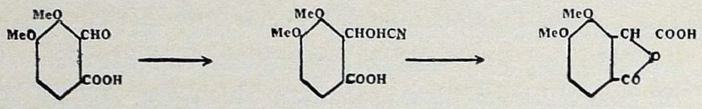


are being examined and an account of these experiments is reserved for a future communication. The chief advantage of these new methods would be that the starting substances would be more readily available substances than the O-aldehydo-acids required for Robinson-Freundler method.

It has now been found that the substituted phthalonic acids (Chakravarti and Swaminathan, loc. cit.), can be reduced to the corresponding phthalide-carboxylic acids in almost quantitative yields. Thus ψ-meconine-carboxylic acid (II) m.p. 175° has been prepared in the following manner :

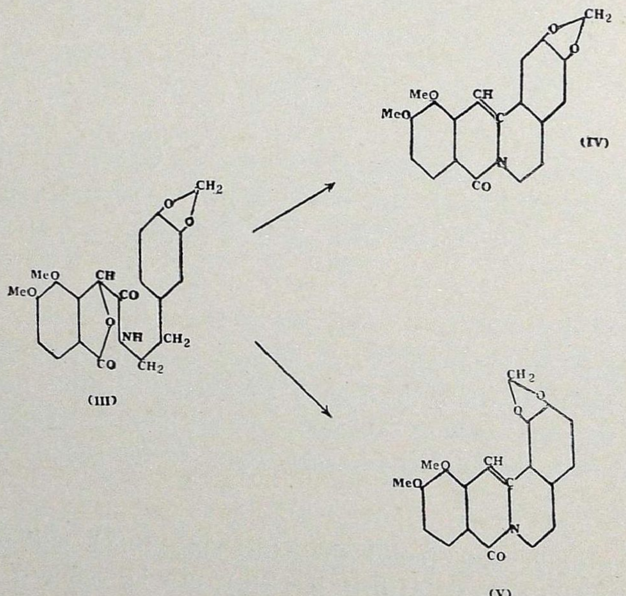


This important acid has also been obtained in an excellent yield by the following alternative route :—



ψ-meconine-carboxylic acid, having thus become readily available, has been utilised to synthesise 2 : 3-methylenedioxy-11 : 12-dimethoxy-oxy-protoberberine and 2 : 3 : 11 : 12-tetramethoxy-oxy-protoberberine, with the object of further elucidating the constitution of these substances.

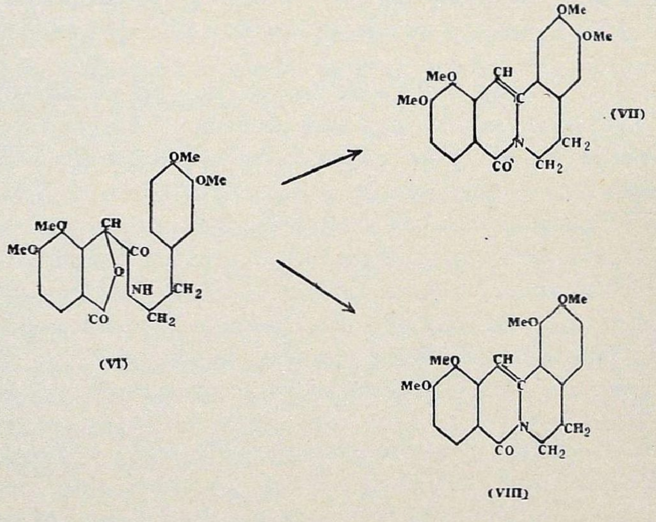
For the synthesis of 2 : 3-methylenedioxy-11 : 12-dimethoxy-oxy-protoberberine, the acid chloride of ψ-meconine-carboxylic acid was con-



densed in benzene solution with β-piperonylethylamine, when ψ-meconine-carboxy-β-piperonylethylamide (III) was formed. When

this was heated with phosphorus oxychloride, and the product decomposed with cold water, and the aqueous solution basified, a basic substance separated which, on reduction with zinc dust and acetic acid was converted into a pale yellow substance m.p. 229°, identical in all respects with 2 : 3-methylenedioxy-11 : 12-dimethoxy-oxy-protoberberine (IV) previously obtained (Chakravarti and Swaminathan J. Indian Chem. Soc., 1934, 11, 109).

In a similar manner, the acid chloride of ψ-meconine-carboxylic acid readily condensed with β-veratrylethylamine, yielding ψ-meconine-carboxy-β-veratrylethylamide (VI). This amide was heated with phosphorus oxychloride during 5 hours on the steam-bath and the product decomposed with cold water. The aqueous solution on being made alkaline, gave a basic substance, which on reduction with zinc dust and acetic acid, was converted into 2 : 3 : 11 : 12-tetramethoxy-oxy-protoberberine (VII) m.p. 190°.



The above syntheses do not afford a rigid proof of the structures assigned to (IV) and (VII), for (III), on treatment with phosphorus oxychloride, might give rise either to (IV) or to (V), and (VI) might give rise to either (VII) or (VIII). The alternative formulae (V) and (VIII) are, however, improbable because their formation necessitates a condensation occurring in the ortho-position to a methoxyl or methylene-dioxy group in preference to the condensation in the far more reactive

para-position, which has so far always been the experience in iso-quinoline condensation of this type.

EXPERIMENTAL.

ψ-meconine-carboxylic acid (*II*). This acid can be readily obtained by the following methods :—

(i) A mixture of ψ-opianic acid (2 g.), pure potassium cyanide (.8 g.) and water (8 c.c.) was allowed to remain during 40 minutes and after the addition of 15% hydrochloric acid (6 c.c.), boiled for ¼ hour. α-cyano-ψ-meconine separated from the hot solution as an oil, which readily crystallised on cooling the liquid. The substance was collected, washed with water, and hydrolysed by boiling with concentrated hydrochloric acid (6 c.c.) for 2 minutes. The liquid was diluted with water (20 c.c.) and, on standing, ψ-meconine-carboxylic acid crystallised (1.5 g.) from the solution. On recrystallising from water, the acid separated as clusters of prismatic needles (containing water of crystallisation) m.p. 175° after drying. (Found in a specimen dried at 100° C, 55.3 ; H, 4.0. $C_{11}H_{10}O_6$ requires C, 55.4 H, 4.2%).

The acid is readily soluble in hot water, and alcohol, but rather sparingly soluble in petroleum ether, benzene or ether. (ii) 5: 6-dimethoxyhomophthalic acid (4 g.) was oxidised with Selinium-dioxide under the conditions previously described (Chakravarti and Swaminathan, J. Indian Chem. Soc. 193, *11*, 717), and the solution of crude phthalonic acid in water (50 c.c.) was reduced by the gradual addition of sodium amalgam (100 g. of 4%). After the reaction was over, the solution was filtered and the filtrate acidified, when ψ-meconine-carboxylic acid, m.p. 175° gradually separated during several hours (1.5 g.) A further quantity of the acid could be obtained from the mother liquors (.5 g.)

ψ-meconinecarboxy-β-piperonylethylamide (*III*). The pure acid, which had been dried at 100° (1 g.), and thionylchloride (5 c.c.) were gently boiled for 2 hours in a reflux apparatus. The excess of thionylchloride was completely removed by distillation below 100° in a vacuum and the crude acid chloride was dissolved in dry benzene (10 c.c.) and gradually added to a dry benzene solution of β-piperonylethylamine (prepared from 1.5 g. of the hydrochloride). The mixture was allowed to remain overnight, and then boiled for 2 hours. On cooling, the amide crystallised out from the solution. The crude amide was stirred up successively with excess of dilute hydrochloric acid, and sodium carbonate solution, and then crystallised from alcohol. It separated in fine silky

needles (1.5 g.) m.p. 177-178°. (Found C, 62.0 ; H, 4.7. $C_{20}H_{19}O_7N$ requires C, 62.3 ; H,4.9.0%).

2 : 3-methylenedioxy-11 : 12-dimethoxy-oxy-protoberberine (IV). The above amide (1 g.) and freshly distilled phosphorus oxychloride (10 c.c.) were heated together on the steam-bath during 5 hours. The mixture was decomposed by means of crushed ice, and the liquid filtered leaving a small residue. The bright yellow filtrate was made just alkaline, when an ochre yellow base was precipitated. The precipitate was collected, washed with water, dried, and then mixed with zinc dust (5 g.) and glacial acetic acid (25 c,c.) The mixture was then boiled for 5 minutes, a second equal portion of zinc dust was added and the boiling continued for half an hour. The filtrate was diluted with a relatively large volume of ethyl acetate, and the solution washed, several times, successively, with dilute hydrochloric acid, with aqueous sodium hydroxide and with water. The solution was dried over potassium carbonate, filtered and the solvent removed by distillation. The pale yellow crystalline residue was crystallised from glacian acetic acid containing its own volume of water, when a mass of almost colourless needles m.p. 229° was obtained. This was identical with 2 : 3-methylenedioxy-11 : 12-dimethoxy-oxy-protoberberine, previously obtained, mixed melting point being not lowered.

ψ-meconinecarboxy-β-veratrylethylamide (VI). The crude acid chloride (obtained from 1 g. of ψ-meconinecarboxylic acid) was dissolved in benzene (10 c.c.) and gradually added to a solution of β-veratrylethylamine (from 1.6 g. of the hydrochloride) in benzene. The mixture was allowed to remain overnight, and then boiled for 2 hours. On concentrating to a small volume and cooling most of the amide separated. The amide, after successive treatment with excess of cold very dilute hydrochloric acid and sodium carbonate solution, was crystallised from benzene. It separated in needless m.p. 150° (1.2 g.) (Found : C, 62.6; H,5.6. $C_{21}H_{23}O_7N$ requires C, 62.8 ; H, 5.7%).

The amide is very easily soluble in alcohol, and sparingly soluble in cold benzene.

2 : 3 : 11 : 12-*Tetramethoxy-oxy-protoberberine (VII).* This was obtained from (VI) under conditions similar to those used for the preparation of 2 : 3 methylenedioxy-11 : 12-dimethoxy-oxy-protoberberine from the amide (III) (See under (IV). The substance thus obtained crystallises in colourless needles m.p. 190° (with previous softening) and was found to be identical with 2 : 3 : 11 : 12-Tetramethoxy-oxy-protoberberine previously obtained ; mixed melting point being not lowered.

On the Diurnal Variation of Atmospherics

By

N. S. Subba Rao,
(Annamalai University)

I. INTRODUCTION

The intimate connection between thunderstorms and atmospherics was recognised long ago, and a systematic study has been carried out by several workers with the object of locating the regions from which originate the atmospherics on the earth. The investigations of Watt,[1] Austin[2] and Appleton[3] point to the conclusion that atmospherics in England originate somewhere in the Mediterranean Sea.

There are five large centres of atmospherics, *viz.*,[4] N. Africa, India, the Malay Peninsula, N. Australia and the region of the Panama Canal. The Committee[5] on Atmospherics and Weather, appointed by the Royal Meteorological Society, organised experiments in which observers in the British Isles, Norway, Germany, France, Spain, Morocco and Madeira recorded the disturbance of the Radio talks and by directional methods located the sources of disturbance. It has been established[6] beyond doubt that the range of reception of atmospherics may reach one to two thousand miles and it is most probable that the range, frequently, if not usually, attains the length of the earth's semi-circumference. It can also be said with certainty that the disturbance from atmospherics is greatest on long waves and least on short waves; and it is believed that below 17 metres the reception of wireless signals is entirely free from atmospherics.

India being one of the main sources of the world's atmospherics, provides ample scope for the study of atmospherics and of their relation to the natural electrical phenomena associated with thunder-

1. Proc. Roy. Soc., Vol. 102, pp. 460-478, 1923.
2. Jour. Frank. Inst., 171, 617 May 1921.
3. Phil. Mag. 1923.
4. Ladner and Stoner: Short Wave Wireless Communication. p. 63.
5. Watson Watt. Nature, Vol. 119, p. 689, 1927.
6. Watson Watt. Jour. Roy. Met. Soc., Vol. 52, p. 199, 1926.

storms. It is the purpose of the present paper to describe a simple method of recording the atmospherics and to study the diurnal and seasonal variations in respect of their intensity and frequency of occurrence. At a time when the popularisation of broadcasting throughout rural India is engaging the public attention a study of the atmospherics which are a menace to wireless reception is quite opportune.

2. EXPERIMENT

(*a*) *Apparatus*.—The apparatus used in the present studies consists of a four valve, straight battery-receiver, the output of which was choke coupled. By employing a choke with two sets of windings the output can be shunted on to a moving coil galvanometer which in conjunction with a rotating drum and bromide paper provided sufficient equipment for recording the atmospherics.

The receiver was kept tuned to a wavelength of 400 metres, the tuning being periodically checked with a calibrated wave-meter. The L.T. and the H. T. voltages were kept during all observations at the same value. Since all factors affecting the set are kept steady it is possible to obtain quantitative measurements from all the records and estimate their variations without any serious error.

The period of the galvanometer was about 1 second and it was fairly well damped. When displaced it returned to rest always before the completion of one oscillation. This was found to be essential in order to prevent the free oscillations of the galvanometer interfering with the records of the atmospherics.

The rotating drum was driven by an electric motor geared down to the requisite speed. After trying various speeds, it was finally found that the one corresponding to a traverse of the spot of light of about 14 cm. per minute exhibited all the necessary details distinctly. The drum was mounted on a screw which advanced it by half an inch parallel to its axis for every complete rotation. Thus using bromide paper of size $10'' \times 12''$, a record could be taken continuously for about 30 minutes at a time. Lower speeds, although more economical, failed to bring out the details.

(*b*) *The choice of wavelength*. It was originally intended to record atmospherics on three wavelengths, one representing the long wave band, another representing the medium wave band and a third representing the short wave band. The idea had to be given up on account

of certain practical difficulties and the observations were confined to a wavelength of 400 metres. This particular wavelength was chosen as a study of atmospherics on this wavelength would be representative of the local reception-conditions.* This wavelength was found convenient for a twenty-four hour study as there is no station in the vicinity, working on this wavelength.

(c) *Duration of the records.* Although at the start, continuous recording throughout the 24 hours was contemplated, it was later given up on account of the prohibitive cost of the records. A comparison was made between results obtained from records over half an hour and those over five minutes and it was found that the agreement was quite close. Continuous recording was therefore given up in favour of five minute records taken at intervals of two hours. Results dealing with the period, 6th—18th October, 1934, are tabulated and discussed later. On certain occasions, when it was found that atmospherics were too frequent, records were taken at about double the speed and as was to be expected the details came out very much more distinctly.

(d) *Automatic time-marking device.* In order to indicate minute intervals on the records, a small electromagnet was included in the circuit of a standard clock and at the end of every minute it was made to interrupt the beam of light falling on the drum for a short interval and thus to provide an accurate automatic time scale on the records. In addition the electric circuit of a slave clock running close to the set produced by induction two kicks in the galvanometer, and these could be used incidentally, for standardising the entire equipment and for correcting for any slight variations in the amplification produced by the receiver.

With the help of the simple arrangement described above very valuable and accurate quantitative estimates of intensity could be obtained.

(e) *Intensity of atmospherics.* From a study of the electric field variations association with atmospherics, with the Cathode Ray Oscillograph, Appleton and Watt[7] classify atmospherics into two main classes, (*a*) quasi-periodics, consisting normally of one complete oscillation of

* Bombay 350.9 metres; Calcutta 370.4 metres; Madras 390 metres; Colombo 428.5 metres.

7. Proc. Roy. Soc., A, 103, pp. 84-102, 1923.

duration 2000 micro-seconds. (b) aperiodics of duration generally 1250 micro-seconds but frequently reaching 0.025 seconds. The wave forms of the main types are given in the paper referred to.

When atmospherics of any of these types are received by a wireless receiver, one half of the above curves is cut off and the remaining portion produces an effect on the galvanometer which is proportional to the total energy of the atmospherics available during this half cycle. The throw of the galvanometer may be taken to be proportional to this energy and this is quite justifiable as the period of the galvanometer is one second and the discharge is over within about 1/500 second i.e., before the galvanometer has moved sensibly from its mean position. As the object of the investigation was mainly to find how a wireless receiver is affected by these disturbances and as the " effect of an atmospheric seems to be more a function of the energy received than of the amplitude of the disturbance ",[8] we can take the throw of the galvanometer as proportional to the audible effect produced in the receiver.

Estimates of the intensities of the atmospherics have been made from the records on a scale of 10 and from these observations the mean intensities are abstracted and shown in Tables I and II. Atmospherics of amplitude less than 3 did not produce much of a disturbance and so in calculating the averages, amplitudes below 3 have been omitted.

(f) *Frequency of occurrence of atmospherics.* As already described, since an automatic time scale was marked on the records, the number of atmospherics received per minute could easily be counted. Certain complications, however, arise on account of the fact that often atmospherics are not single impulses but consist of strings of impulses and reception is seriously interfered with, and sometimes rendered impossible, by these strings or groups creating " a serious of crashes, bangs and rattles ".[9]

When the atmospherics come in groups following each other in quick succession, it is not possible to estimate the strength of the individual components of the group and in such cases, the throw has been taken as representing the intensity of the group. This will give an accurate measure of the strength of the first member of the group, provided the second member comes later than ¼ period of the galvanometer. Nevertheless, the number of components in any group could

8. Palmer: Wireless principles and Practice, p. 287.
9. Ibid, p. 285.

easily be counted from the records, as each individual atmospheric produces a slight thickening of the curve at the point where it arrives, and if an atmospheric of sufficient intensity arrives in a favourable phase of the galvanometer motion, it will show itself as a separate atmospheric.

3. RESULTS.

In Table I are abstracted the results of the preliminary observations made between the 6th and 9th October 1934, at Annamalainagar (Lat. 11° – 25′N., Long. 79° – 42′E.). As the object of the investigation was mainly to study how a broadcast receiver is affected by the atmospherics, observations were confined from midday to 10 p.m., as this period includes the regular hours of 'listening in'. The results are plotted on squared paper and shown in Fig. 1.

TABLE I.

Results of observations from 6-10-34 to 9-10-34 from midday to midnight each day.

	6-10-34		7-10-34		8-10-34		9-10-34	
Time.	Average Intensity.	No./Min.	Average Intensity.	No./Min.	Average Intensity.	No./Min.	Average Intensity.	No./Min.
12 Noon	Nil	Nil			5	1	7	2
1 P.M.					4	24		
2 P.M.	4	6	5	30	5	24	5	28
4 P.M.	4	13	5	33	5	32	5	33
6 P.M.	4	22	4	23	5	34	6	14
8 P.M.	4	25	4	23	5	34	5	14
10 P.M.	5	18	4	23	6	13	6	7

The continuous line indicates the intensity variations and the dotted line, the variations in the number of atmospherics received per minute. When a group of atmospherics arrives, it is counted as one, irrespective of the number of components. The components are in some cases as many as twelve, but these come in such quick succession (usually within half a second) that it is quite legitimate to consider them as a unit for the purpose of the present investigation.

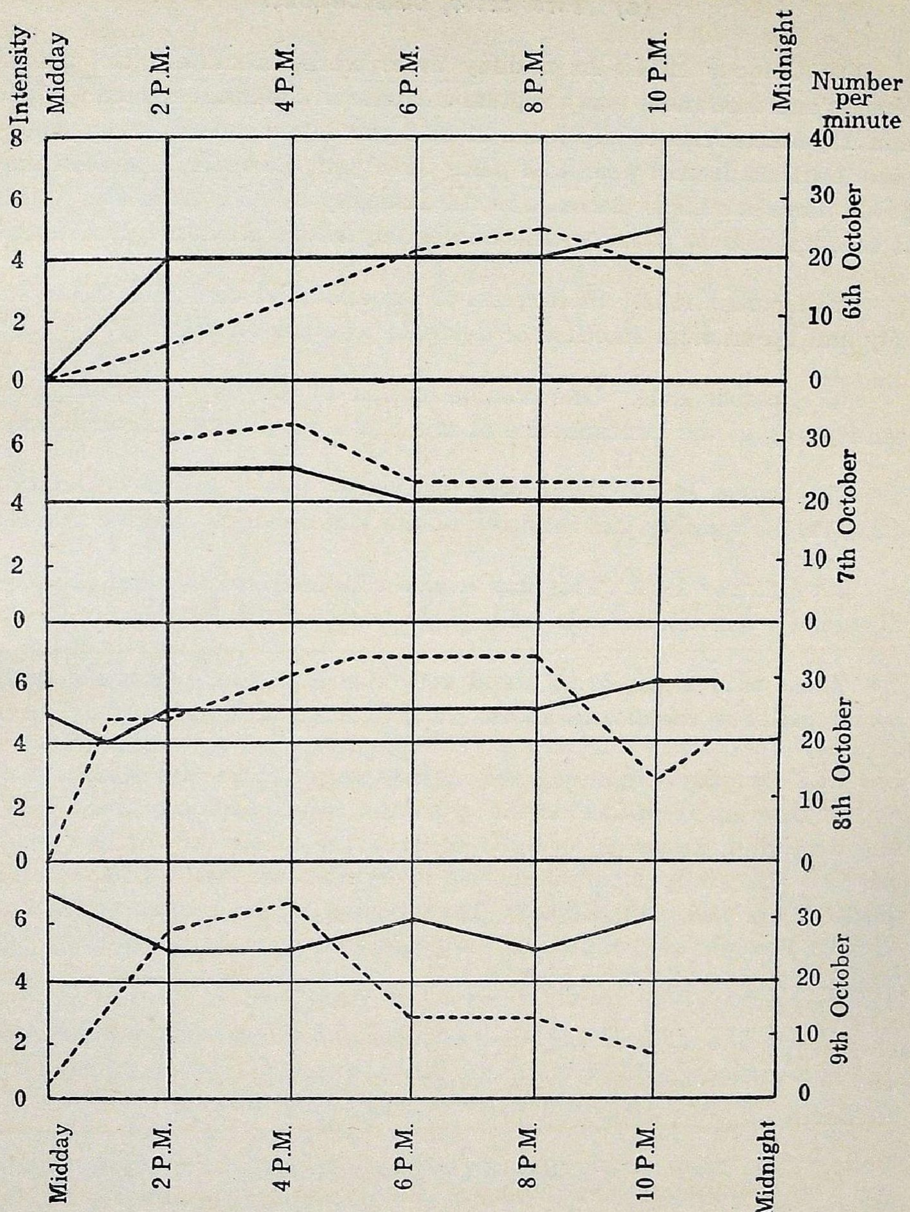


Fig. 1.

Certain regularities are clearly borne out by these curves.

(a) *First set of observations.*

6th October 1934. At midday there were absolutely no atmospherics and then there was a regular increase in the number received per minute, which reached the value 25 at 8 p.m. The intensity was practically constant from 4 p.m., to 8 p.m. At 8 p.m., however, it is seen that while there is a slight increase in the intensity by 25% from 4 to 5, this is accompanied by a fall in the number by about the same percentage.

7th October 1934. In contrast to the above we find that the intensity and the number increase or decrease together on this day.

8th October 1934. One notable feature of this day is the large intensity (5) of the atmospherics at midday, a very unusual condition.

The curves bring about very distinctly the negative correlation between the number and intensity of the atmospherics at three points.

9th October 1934. This day is also characterised by high intensity at midday, which continues with slight variation till 10 p.m.

These curves also bring about very clearly at four points the negative correlation mentioned above.

The four days discussed above show very severe atmospheric activity, rendering reception on the broadcast band absolutely impossible; the maximum intensity recorded being 7, the maximum number being 34, i.e., one group of atmospherics every two seconds. The intensity maxima are not well defined. The maxima in the number of atmospherics received per minute are attained at 8 p.m., on the 6th and 8th, and at 4 p.m., on the 7th and 9th.

There is a distinct negative correlation between the intensity and the number on the 6th, 8th and the 9th. In contrast within this, the two quantities show a distinct positive correlation on the 7th.

(b) *Second set of observations.*

The second set of observations—table II—cover the period from the 11th to 18th October 1934. Observations were made throughout the twenty four hours of each day and the results are plotted in Fig. II. In doing so the day is reckoned from 12 noon to 12 noon. This method of reckoning is found to be suitable for bringing out the diurnal variations most prominently.

TABLE II.

Results of observations from 11-10-34 *to* 18-10-34.

Time.	11-10-34 to 12-10-34		13-10-34 to 14-10-34		14-10-34 to 15-10-34		15-10-34 to 16-10-34		16-10-34 to 17-10-34		17-10-34 to 18-10-34	
	Average Intensity.	No./Min.	Average Intensity.	No./Min.	Average Intensity.	No./Min.	Average Intensity.	No./Min.	Average Intensity.	No./Min.	Average Intensity.	No./Min.
12 Noon	6	1	Nil	Nil	7	2	5	6	9	1	Nil	Nil
2 P.M.			Nil	Nil								
4 P.M.	4	13					6	10	6	7	5	5
6 P.M.	6	5	6	5			5	25				
8 P.M.	4	9	4	9	5	26			7	1	5	20
10 P.M.	4	9	7	17	6	20	6	11	7	6	6	20
Midnight	4	10	7	17			7	13	9	14	7	5
2 A.M.	4	2	6	16			7	16	8	20	7	7
4 A.M.	4	4	7	26			7	22	7	22	6	2
6 A.M.	7	2					7	3	5	3	Nil	Nil
8 A.M.	Nil	Nil	6	1	7	7	5	1	Nil	Nil	Nil	Nil
12 Noon	Nil	Nil	7	2	5	6	9	1	Nil	Nil	Nil	Nil

11th–12th October 1934. One notable feature is the high intensity at midday with two definite maxima at 6 p.m., and 6 a.m., the intensity dropping to zero between 6 and 9 a.m.

As regards number the maxima occur at 4 p.m., and midnight.

There is a very distinct negative correlation between the intensity and the number.

On the whole, in spite of the large intensity exhibited, the conditions of reception cannot be classed as hopeless.

12th–13th October 1934. No records were taken.

13th—14th October 1934. Atmospheric activity at midday is nil. A distinct peak in intensity is observed at 6 p.m., and a slight reduction at 8 p.m. Thereafter the intensity is practically steady with very minor variations.

The number shows a distinct maximum (26) at 4 a.m. and then a sudden drop reaching the value 1 at 8 a.m.

The atmospheric activity may be considered to be very severe between 8 p.m., and 4 a.m.

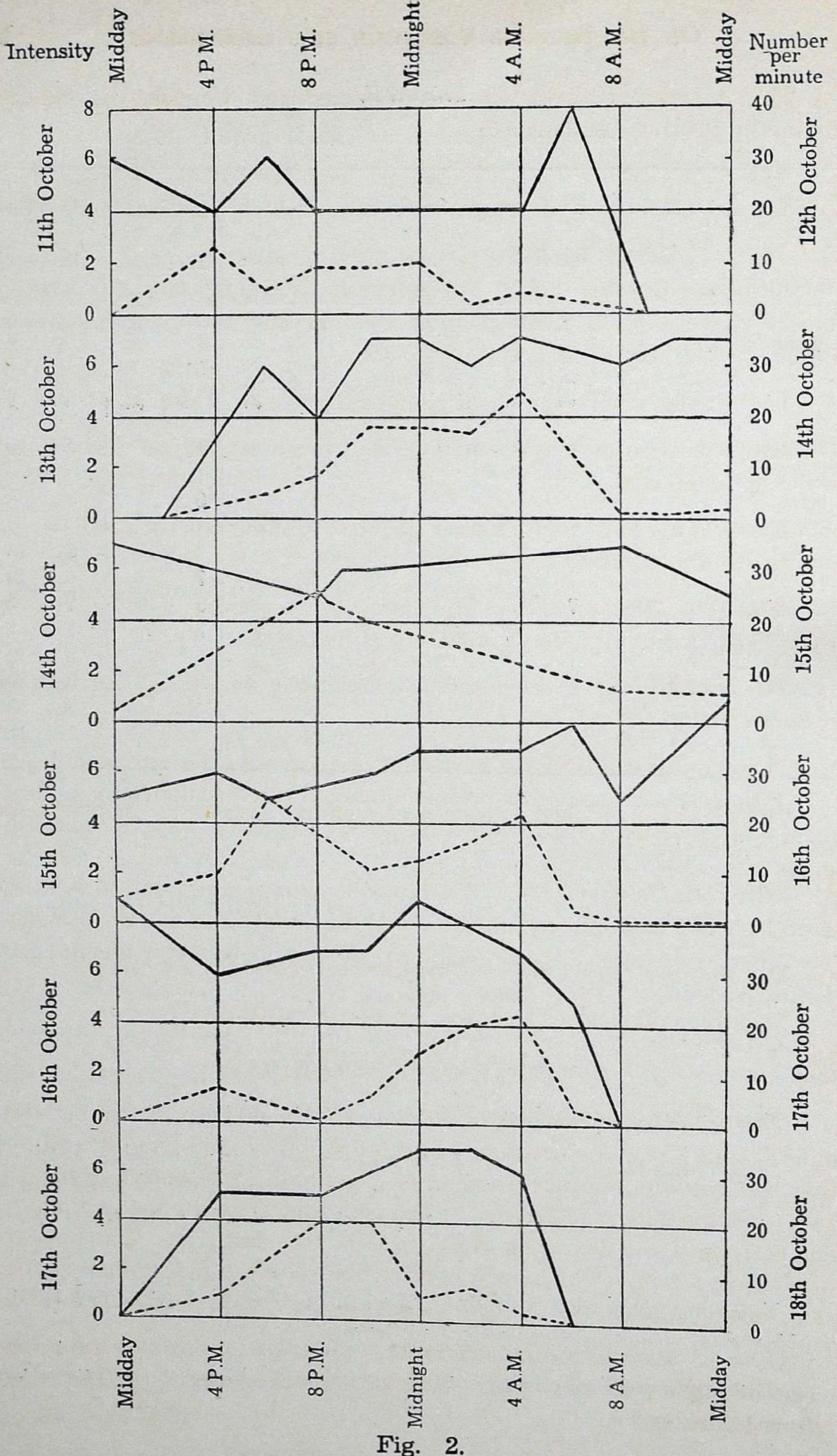

Intensity
Number per minute
Midday
4 P.M.
8 P.M.
Midnight
4 A.M.
8 A.M.
Midday
11th October
12th October
13th October
14th October
14th October
15th October
15th October
16th October
16th October
17th October
17th October
18th October
8
6
4
2
0
40
30
20
10
0

Fig. 2.

The correlation between the number and intensity is neither distinctly positive nor negative.

14th–15th October 1934. A distinct negative correlation is evident. In contrast with the two previous records, the activity has not ceased between 8 a.m., and 12 noon.

15th–16th October 1934. The intensity at midday is high. The intensity curve exhibits three distinct maxima, one at 4 p.m., another at 6 a.m., and a third at 12 noon on the 16th.

The number curve shows maxima at 6 p.m. and 4 a.m.

The atmospheric activity may be said to have attained a maximum at 6 p.m. and 4 a.m.

There is again a very distinct negative correlation between the intensity and the number.

16th–17th October 1934. The intensity at midday is exceptionally high. The maxima occur at midday and midnight.

The number curve shows two maxima, one at 4 p.m., and another at 4 a.m.

The atmospheric activity is very severe between 10 p.m., and 6 a.m.

There is again a clear evidence of negative correlation between the number and the intensity.

17th–18th October 1934. The intensity curve shows only one maximum between midnight and 2 a.m. The intensity drops to zero at 6 a.m.

The number curve shows a maximum between 8 and 10 p.m.

Negative correlation is shown but not very distinctly.

4. GENERAL CONCLUSIONS.

The intensity curve attains in general a maximum either between midday and 2 p.m., or between 4 and 6 p.m. It is seen from the curves that the maximum occurs between 12 noon and 2 p.m., on the 6th, 8th, 14th, and the 16th. (Records for the 10th and 12th are not available); and between 4 and 6 p.m., on the 11th, 13th, 15th and 17th. This appears to point to a forty-eight hourly cycle of variations, but the observations at present available are too few to warrant any such definite inference.

In some cases a second maximum appears to occur any time between midnight and daybreak. The variations, however, do not show any regularities.

The number curves show a maximum either between 2 and 4 p.m., as on the 7th, 9th, 11th and the 15th (No record was taken on the 13th). or between 6 and 8 p.m. as on the 6th, 8th and the 14th (records for the 10th and 12th are not available).

The second maximum appears to occur between midnight and 4 a.m., as on the 12th, 14th, 16th and the 17th or at midnight as on the 18th.

The variations in the number curves also appear to point to a forty-eight hourly cycle.

The periods of maximum atmospheric activity and the probable origin of atmospherics.

Taking into consideration both the intensity and the number, the periods of severe atmospheric activity may be taken on the days discussed above as follows :—

6th.	8 p.m.
7th.	4 p.m.
8th.	4 p.m. to 8 p.m.
9th.	4 p.m.
11th–12th.	Between 4 p.m., and midnight.
13th–14th.	4 a.m.
14th–15th.	(Detailed record is not available).
15th–16th.	4 a.m.
16th–17th.	4 a.m.
17th–18th.	10 p.m.

The periods of maximum atmospheric activity appear to fall into three divisions :—

1. Afternoon about 4 p.m.
2. Early night 8 to 10 p.m.
3. Early morning about 4 a.m.

This seems to indicate their origin.

" The observations[10] made by Challenger show that the frequency of thunderstorms at sea have a pronounced maximum between 2 and

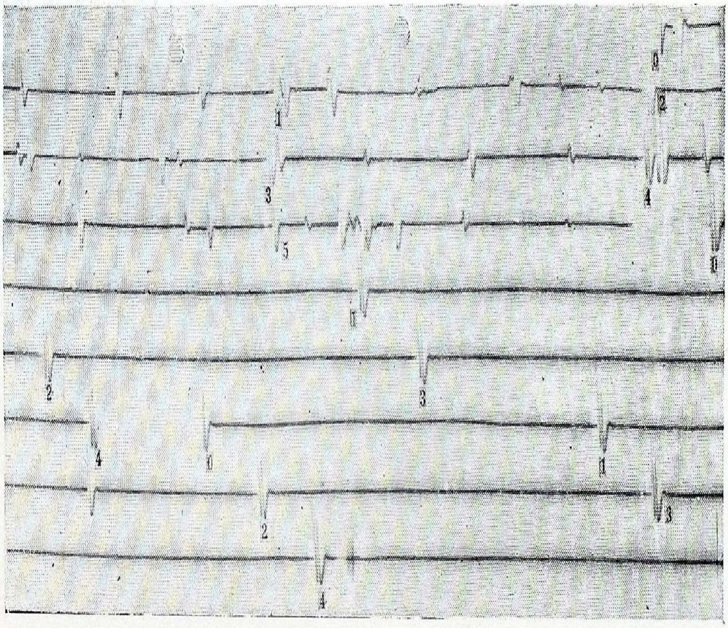
10. Ency. Britt. Vol. 15, p. 345.

Wednesday 17th October 1934.

6 A.M.

8 A.M.

12 Noon.

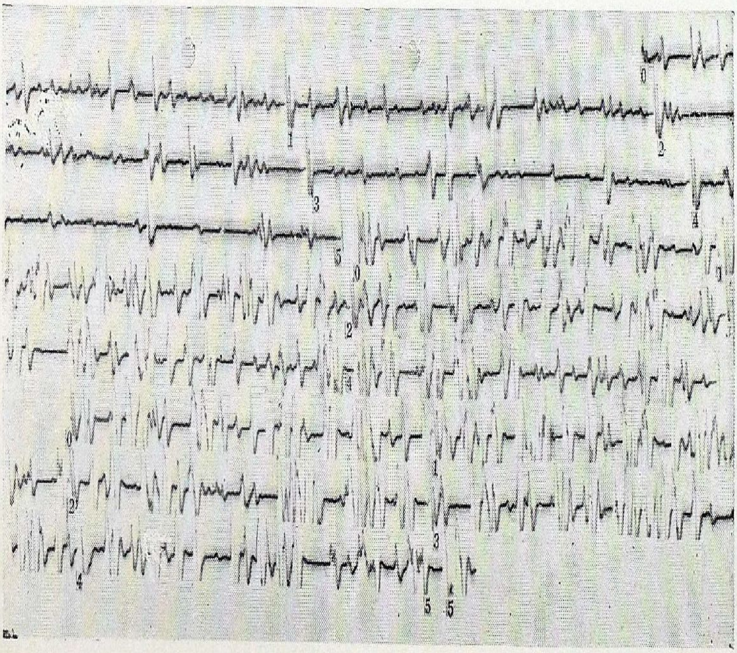


Wednesday 17th October 1934.

4 P.M.

7 P.M.

10 P.M.

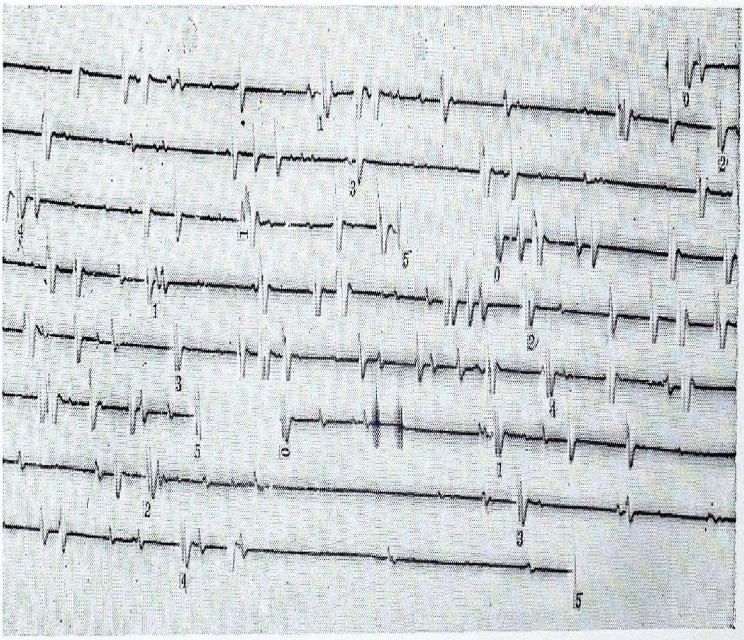


Records of Atmospherics.

17-10-34.
Midnight.

18-10-34.
2 A.M.

4 A.M.



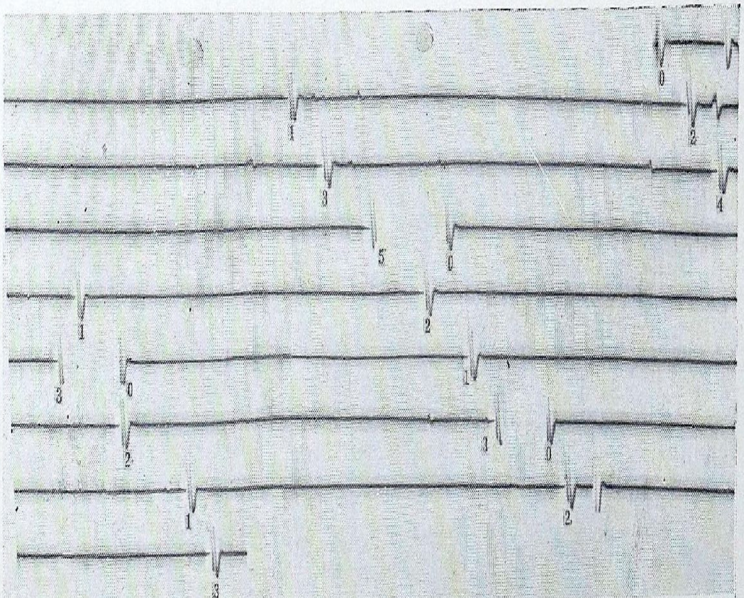
Thursday 18th October 1934.

6 A.M.

8 A.M.

10 A.M.

12 Noon.

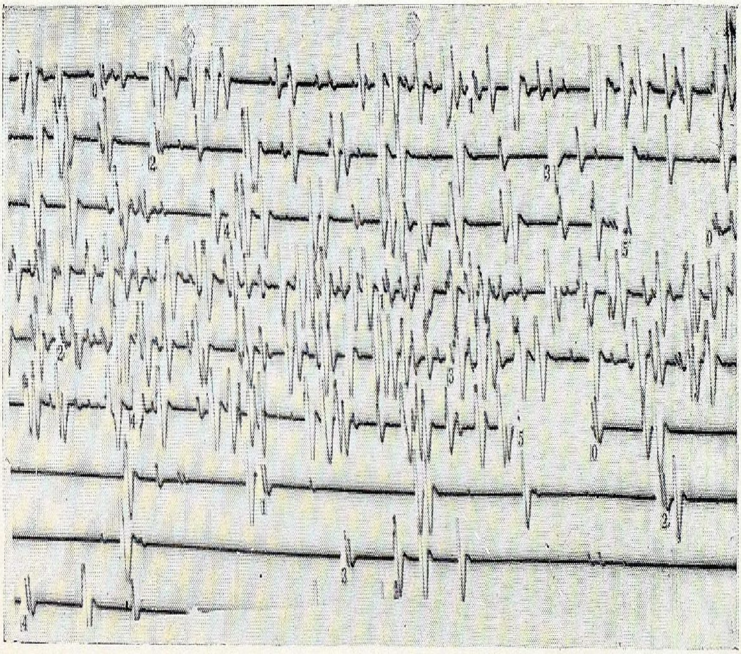


Records of Atmospherics.

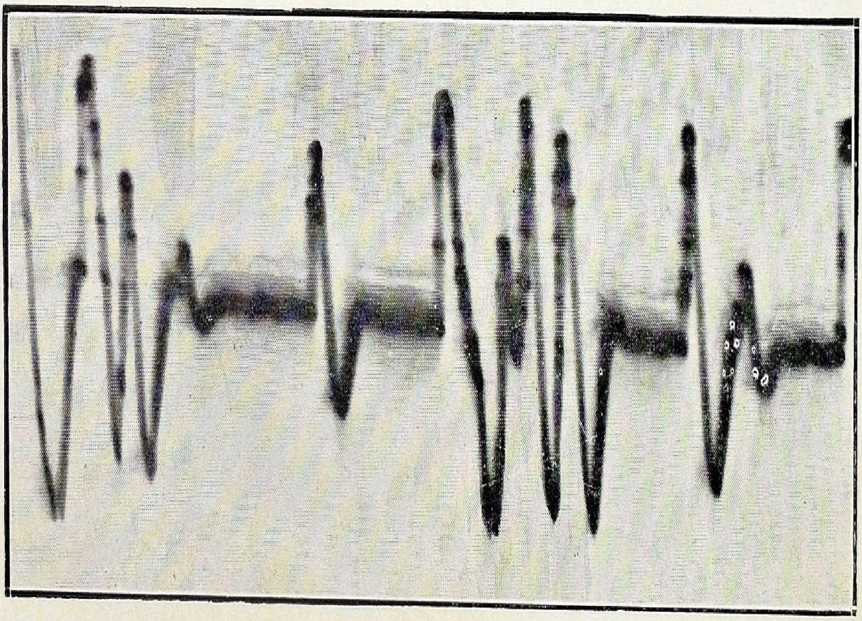
8-10-34.
10 P.M.

11 P.M.

9-10-34
7-45 A.M



Record of Atmospherics.



Enlargement of a section (at the end of the fifth minute) of the record taken at 11 P.M. on 8—10—34, showing the details clearly.

4 a.m., while the occurrence of lighting only shows a maximum between 8 and 10 p.m. Over the land heat thunderstorms occur most frequently during the afternoons; but certain types associated with the line of separation between warm and cold air currents shows no special preference to day or night ".

The work of Watson Watt[11] carried out in England shows the correlation between the apparent sources of atmospherics and their meteorological environment. Of 490 cases examined, 25% fell within 250 kilometers of reported thunder, a further 28% were associated with more distant thunderstorms or with squall phenomena, 21% more with rain, 13% fell on barometric minima leaving 13% uncorrelated.

The origin of the atmospherics between the 13th and the 14th showing maximum activity at about 4 a.m. may be due to the " unsettled conditions in the Bay of Bengal which caused thunder-showers along the Madras Coast, lower Burma, Bombay, Bengal, Malabar and Ceylon "[12]

Those on the 7th, 8th, 9th and 11th showing maximum activity at about 4 p.m., may have their origin in the thunderstorms[12] reported from Assam, Central Provinces, Mysore etc.,

Similarly we may attribute the maximum activity between 8 and 10 p.m. on the 6th and 11th to atmospherics having their origin in lighting.

5. CONCLUSION.

The period during which the observations embodied in this paper were carried out is too short to justify any generalisations regarding the effect of atmospherics on wireless reception and as further observations are in progress. There is, however, one point which appears to be clearly borne out by the records, viz., the negative correlation, between the intensity and the number of atmospherics already discussed. In 80% of the curves given above a distinct negative correlation is indicated.

In conclusion, I have great pleasure in expressing my best thanks to Dr. S. Ramachandra Rao, Professor of Physics, Annamalai University, for facilities and encouragement, and to Dr. A. L. Narayan, Assistant Director, Kodaikanal Observatory, for some of the references. I have also to express my appreciation of the help rendered by Mr. P. S. Varadachari, Research student, and Mr. M. V. Subramaniam, Mechanic, Annamalai University in connection with the recording of atmospherics.

11. Proc. Phy. Soc., Lond., 37, 230, 1925.
12. Indian Daily Weather Reports dated 7th to 19th Oct. 1934.

Median of Three Populations—A Simple Construction

By

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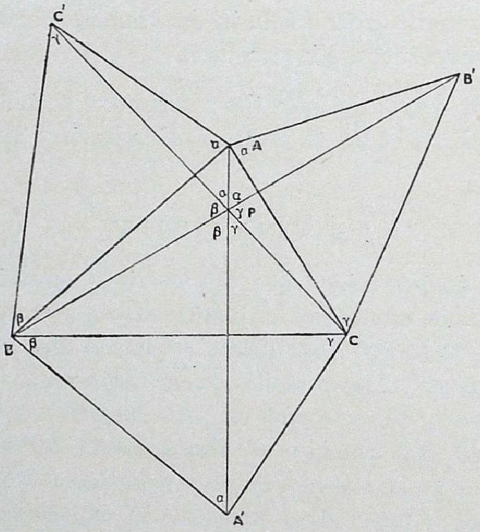
(*Annamalai University*)

Case of equal populations. Let A, B, C, be the three points of concentration. Then it is well known that the point for which the sum of the distances from the three points of concentration is least is such that $\angle APB = \angle BPC = \angle CPA = 120°$. When such a point exists it is usually found by the intersection of the arcs of two circles. The point will exist if none of the angles of the triangle ABC is greater than 120°. It is called the Fermat point.



In this special case a simpler construction for finding the point is available. Let equilateral triangles be described on the sides of the triangle ABC externally to it. If A′, B′, C′ be the vertices of these triangles (corresponding to the sides BC, CA, AB respectively), it is easy to show that AA′, BB′ and CC′ are equal and concurrent. That this point is the Fermat point has been proved by analytical and vectorial methods.[1] It

1. See Morley and Morley, *Inversive Geometry*, p. 207.

is easy to obtain the result from very elementary considerations. For Q being any other point in the plane $QB + QC \geqslant QA'$. Therefore $QA + QB + QC \geqslant QA + QA' > AA'$ and $AA' = PA + PA' = PA + PB + PC$. That is, P is the Fermat point and the minimum distance of travel is AA′.

The Fermat point can therefore be obtained more simply as the intersection of the two straight lines AA′ and BB′. When any one of the angles is greater than 120°, the point P so obtained will be outside the triangle and will not be the median. It is known that the vertex corresponding to the obtuse angle is the median then.

Case of unequal populations. This construction can be generalised to include the case of unequal populations. Let the populations T_1, T_2, T_3 at A, B, C be such that they could be represented by the sides of a triangle $\alpha\beta\gamma$ (say), α, β, γ corresponding to the sides T_1, T_2, T_3 respectively. In the special case treated above $\alpha\beta\gamma$ becomes equilateral. In the general case let triangles similar to $\alpha\beta\gamma$ be described on the sides of the triangle ABC externally in the following manner. In A′BC, the angle $A' = \alpha$, $\angle A'BC = \beta$, $\angle A'CB = \gamma$; in B′CA, the angle $B' = \beta$, $\angle B'CA = \gamma$, $\angle B'AC = \alpha$ and so on. [See Figure]. Join AA′, BB′, CC′. If AA′ and BB′ cut at P, the triangles ACA′ and BCB′ are similar and hence PCA′B and PCB′A are cyclic quadrilaterals. It is then easy to show that CC′ also passes through P. The angles BPC, CPA, APB are respectively $\beta + \gamma$, $\gamma + \alpha$, $\alpha + \beta$ or $180° - \alpha$, $180° - \beta$, $180° - \gamma$. P is thus the median required.[2]

That this is the median can be proved from elementary considerations. We have

$$BC/T_1 = CA'/T_2 = BA'/T_3 \text{; and}$$

$$PC \,.\, BA' + PB \,.\, CA' = PA' \,.\, BC. \quad \text{Therefore}$$

$$T_3 \,.\, PC + T_2 \,.\, PB = T_1 \,.\, PA' \quad \text{and}$$

$$T_1 \,.\, PA + T_2 \,.\, PB + T_3 \,.\, PC = T_1 \ (PA + PA') = T_1 \,.\, AA'.$$

Q being any other point in the triangle ABC, we have

$$QB \,.\, CA' + QC \,.\, BA' \geqslant BC \,.\, QA' \text{;} \quad \text{that is}$$

$$T_2 \,.\, QB + T_3 \,.\, QC \geqslant T_1 \,.\, QA'. \quad \text{Therefore}$$

2. Refer Eqn. 4, p. 60: Mr. S. Subramaniam, "On the Centre of Population," Journal of the Annamalai University, Vol. III, No. 1.

$T_1 . QA + T_2 . QB + T_3 . QC \geqslant T_1 \ (QA + QA') > T_1 . AA'.$

Hence P is the point for which the sum

$T_1 . PA + T_2 . PB + T_3 . PC$ is least.

This point will possess this property only if it be inside the triangle ABC, (i.e.) if AA′, BB′, CC′ are all within the arms of the angles of the triangle.[3] If, for instance, α be greater than $180° - A$, the lines BB′ and CC′ will fall outside the triangle and therefore P will be outside the triangle. That such a median should exist within the triangle, $\alpha + A$, $\beta + B$, $\gamma + C$ should all be less than 180°.

Whenever this condition is satisfied the position of the point P can be got as the intersection of two straight lines AA′ and BB′, A′ and B′ being the vertices of triangles described on BC and CA similar to $\alpha\beta\gamma$ in the manner specified above. This construction appears to be much easier and less susceptible to error than the usual one of intersection of arcs of circles.

No construction is necessary for finding the median when (*i*) $\alpha + A$ or $\beta + B$ or $\gamma + C$ is greater than 180° and when (*ii*) the populations are such that they cannot represent the magnitudes of the sides of a triangle. In these cases the median is one of the vertices of the triangle.

The lines AA′, BB′, CC′ are concurrent even if the triangles be described internally; this point is not considered here as it has no immediate practical application.

3. See my "Note on the Centre of Population," p. 279-282, Vol. III, No. 2, Journal of the Annamalai University, where it is shown that if the $\angle A > 180° - \alpha$, A will be the centre.

On Linear Complexes corresponding to Subrational Pedal Quartics on a Quadric

BY

K. RANGASWAMI,* (*Research Student*)
(*Annamalai University*)

1. Let $\Sigma(a_i + \varrho) u_i^2 = 0$ $(i = 0, 1, 2, 3)$ represent a pencil of class quadrics, referred to their common self polar tetrahedron $\triangle$. We shall, for convenience, call such a pencil a "confocal system" (C. S.) of quadrics. The term "confocal" usually implies that the Absolute of the metrical three-space is a member of the quadric system; for our purpose it is unnecessary, however, to specify whether the Absolute is a proper or a singular quadric of the pencil or which particular quadric is chosen as the Absolute. Further, we shall refer to the member of the C. S. for which $\varrho = 0$ as the quadric Q.

The locus of poles of a plane α with respect to the quadrics of the C. S. is a line a called[1] the *axis* of the plane α; the plane α will be called the *normal plane* of a, and its pole with respect to Q, the *normal pole* of the axis a. The axis of a tangent plane *to a quadric of the C. S.* will be called the *normal* to this quadric at the point of contact with the plane. The totality of axes of the C.S. constitute a tetrahedral complex C_2 (Reye's complex of axes) having $\triangle$ for the fundamental tetrahedron. Since a quadratic complex has four lines in common with every regulus, there are four generators of each system on Q which are axes. These lines besides being generators of Q touch all other quadrics of the C. S. The normal planes of these eight generators, called the *cyclic planes* of Q, contain their axes and touch all the quadrics of the C. S.

Now, given any axis a, its polar line a' with respect to Q (more generally with respect to any quadric having $\triangle$ for a self polar tetrahedron) is also an axis. It can be shown that the normal planes α, α' of a, a' correspond to each other in a Cremona cubic plane transformation Γ of the desmic type, that is, the two planes are conjugate with respect

* I am indebted to Prof. A. Narasinga Rao for guidance and criticism in preparing this note.

1. Throughout this note, the notation and terminology are the same as that used in a paper on "The theory of normals to a Quadric" which will be published shortly.

to all the quadrics of a net inscribed to two tetrahedra $\triangle_1$, $\triangle_2$ forming with $\triangle$ a desmic-system. Since a will coincide with a' only when it is a generator of Q, it follows that the fixed planes of Γ are the eight cyclic planes of Q, while its singular planes are the faces of $\triangle$. The lines of intersection of corresponding planes in the transformation Γ generate a cubic complex C_3, which is constituted by the totality of generators of the net N of quadrics touching the eight cyclic planes of Q. If $p_{ij} = x_i y_j - x_j y_i$ are line coördinates, the cubic complex C_3 has the equation:

$$C_3: \quad A_0 p_{01} p_{02} p_{03} + A_1 p_{10} p_{12} p_{13} + A_2 p_{20} p_{21} p_{23} + A_3 p_{30} p_{31} p_{32} = 0$$

where $A_0 = a_0/(a_0 - a_1)(a_0 - a_2)(a_0 - a_3)$ etc. . . . .

Thus, through each line a of C_3 there pass two planes α_1, α_2 whose axes a_1, a_2 are polar lines with respect to Q. If, however, a is an *axis*, the axes a_1, a_2 lie in the normal plane α of a, and hence α is the tangent-plane to Q at their point of intersection. Thus a being the axis of a tangent plane to Q is, by definition, a normal to Q. Hence the normals to the quadric Q of the C. S. belong both to the tetrahedral complex C_2 and the cubic complex C_3 associated with Q.

2. Any linear complex

$$C: \quad \Sigma c_{ij} p_{ij} = 0 \quad (i, j = 0, 1, 2, 3)$$

determines a (2, 2) congruence whose lines belong both to C and the tetrahedral complex C_2. The locus generated by the normal poles of the axes of this congruence is a quadric H circumscribed to $\triangle$ whose equation is

$$H: \quad \Sigma\, c_{ij}(a_i - a_j) x_i x_j / a_i a_j = 0 \qquad (i, j = 0, 1, 2, 3).$$

This quadric has been called the *Apollonian quadric* associated with the linear complex C (with the base quadric Q of the C. S.). Since the coefficients of H are linear in those of C, the correspondence between a linear complex and its associated Apollonian quadric is one-to-one.

From the definition of the Apollonian quadric it follows that the quartic curve in which the Apollonian quadric H intersects Q is the locus of points the normals at which to Q belong to the linear complex C. This quartic may be called the *pedal quartic* of the linear complex C. Further, we note that the unique member in the pencil of quadrics through the pedal quartic outpolar to Q is the Apollonian quadric associated with the linear complex C.

Now, if an Apollonian quadric H is doubly apolar to Q, it cuts out a subrational[2] pedal quartic on Q. From the equation of the Apollonian quadric it is easily seen that the constants of the linear complex satisfy, in this case, the relation :

$$A_0c_{23}c_{31}c_{12} + A_1c_{23}c_{02}c_{03} + A_2c_{31}c_{03}c_{01} + A_3c_{12}c_{01}c_{02} = 0$$

This is exactly the condition that $(C)^3 = 0$ may be apolar to the cubic complex $C_3 = 0$. We have thus the following main theorem of this note viz.,

The linear complexes corresponding to subrational pedal quartics on Q are apolar (in the above sense) to the cubic complex C_3.

3. The geometrical significance of the apolarity of a linear complex C to the cubic complex C_3 is worthy of notice. Let $\triangle_1$, $\triangle_2$ be a pair of tetrahedra forming with $\triangle$ a desmic system. It is easily seen from equations that the two nets of linear complexes associated with Apollonian quadrics circumscribed to $(\triangle, \triangle_1)$, $(\triangle, \triangle_2)$ are mutually apolar. Further, since the two nets of Apollonian quadrics have no common member, so are the nets of linear complexes. In such pairs of apolar nets of linear complexes, the regulus of lines common to either net are the directrices of special complexes of the other net. The two reguli determine uniquely a quadric Φ on which they constitute the two systems of generators. This quadric passes through the vertices of $\triangle_1$, $\triangle_2$ (hence it has $\triangle$ for a self polar tetrahedron) and contains the axes of the polar planes of the vertices of $\triangle_1$, $\triangle_2$ with respect to Q. These are the eight generators of Φ belonging to the tetrahedral complex C_2, the generators through the vertices of $\triangle_1$ belonging to one system and those through the vertices of $\triangle_2$ belonging to the other system on Φ. As we vary the pair of tetrahedra $\triangle_1$, $\triangle_2$ we get different quadrics Φ, all having $\triangle$ for a self polar tetrahedron.

In particular, if Φ is any quadric of the net N (and in no other case) the vertices of the two tetrahedra $\triangle_1$, $\triangle_2$ inscribed in Φ lie also on Q. In other words, Q is circumscribed to the two desmic tetrahedra $\triangle_1$, $\triangle_2$ inscribed in a quadric of the net N. Since[3] any two quadrics of different desmic nets are doubly apolar, the nets of Apollonian quadrics cir-

2. Subrational (2, 2) curves on a quadric S are those, which admit ∞^1 inscribed generator quadrangles of S. They are, necessarily, either the intersection curves or contact curves of S, with quadrics doubly apolar to it. (*Vide* "Cubic transformations associated with a desmic system" by Dr. R. Vaidyanathaswamy, supplement to *Jour. of the Ind. Math. Soc.*, Vol. XVII (1927), p. 83.).

3. Vide "Cubic transformations, etc. . . ." *loc cit.* p. 87.

cumscribed to $(\triangle, \triangle_1)$, $(\triangle, \triangle_2)$ in this case, are doubly apolar to Q. Thus every linear complex C apolar to C_3 so that its associated Apollonian quadric is doubly apolar to Q contains a regulus of a quadric of the net N and, therefore, a regulus of C_3.

4. If we represent a linear complex in [3] by a point of [5], by which the special linear complexes will be represented by the points of a quadric variety V in [5], to every point [5] there will correspond a linear complex on the one hand and hence also an Apollonian quadric. The equation $C_3 = 0$ will represent a cubic locus in [5] the points of which will correspond in [3] to linear complexes whose associated Apollonian quadrics are doubly apolar to Q. If Φ is any quadric of the net N and $\triangle_1$, $\triangle_2$ the unique pair of inscribed tetrahedra in desmic relation to $\triangle$, the two nets of Apollonian quadrics circumscribed to $(\triangle, \triangle_1)$, $(\triangle, \triangle_2)$ will correspond to two generating planes of C_3 in [5]. Further, since the linear complexes corresponding to these two nets of Apollonian quadrics form two mutually apolar nets, the two generating planes of C_3 in [5] are polar planes with respect to V. Thus the cubic locus C_3 in [5] has ∞^2 generating planes and is self reciprocal with respect to V.

Abnormal Flowers of Cassia Fistula, Linn

By

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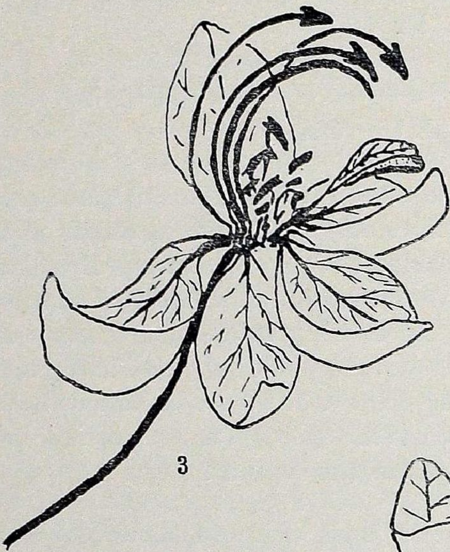
(Annamalai University)

Last year, about this time, one of us (T. S. Raghavan) came across rather frequent cases of polyphylly of the gynœcium in *Cassia fistula,* a phenomenon which Prof. Narasinga Rao of the Madras Presidency College had also observed. While examining the flowers of the same tree this year, with a view to ascertaining if the phenomenon had any bearing on seasonal changes or showed any periodicity, many types of abnormalities were met with which are recorded below. Reference to Masters[1] showed that the genus Cassia has not been known to exhibit any of the abnormalities herein noted.

[Prolification is the production of buds (flower buds or leaf buds) either in the centre of a flower or axillary to some of the floral leaves.]

Median Floral Prolification. (Fig. 1). The flower is admitted to be 'morphologically a determinate stem with appendages which are homologous with leaves'[2] which ceases to grow after the formation of the carpels. In such cases as these, it takes on new growth. Such median floral prolifications are said to be frequent in "plants with an indefinite inflorescence . . . . . . and where there is a stalk supporting the pistil" (Masters, p. 122). Occasionally it has been recorded in the Leguminoseae (*Medicago, Pisum,* etc.), but in all such cases, the prolonged axes have been known to be terminated by a floral bud. In this case, however, the axis has grown into an inflorescence bearing a number of buds in a racemose manner. A part of the carpel is also found, in a modified condition, bearing few ovules, so that the question of "the pistil being metamorphosed into a stem bearing flowers" does not appear to arise ([1] p 124) which conclusion

1. Masters (1869): Vegetable Teratology (Ray. Soc.).
2. Eames (1931): Refutation of the theory of carpel polymorphism. Am. Jour. Bot., Vol. 18, p. 147.



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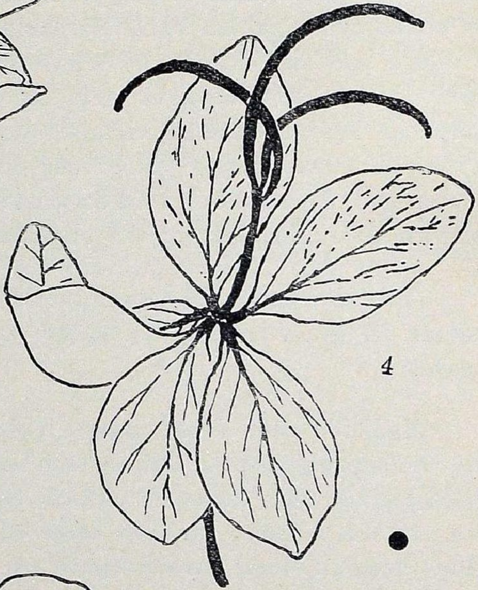

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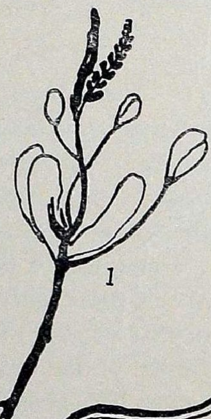

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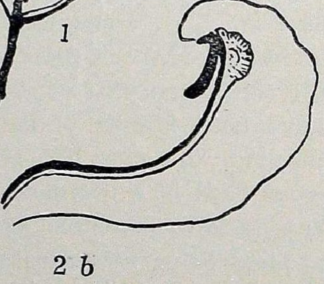
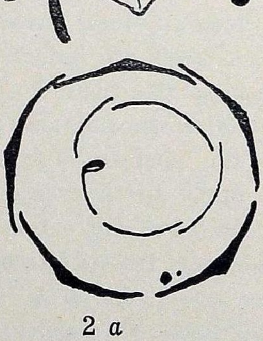


2 *b*



2 *a*

seems to have been arrived at by some, on account of the frequent absence of carpels in cases of median prolification. The median prolification is not here accompanied by any other deviation in the floral parts, except for a slight alteration in their position.

Axillary Floral Prolification. (Fig. 2). Here one normal flower bud springs from the axil of one of the anterior sepals. Associated with this is the suppression of two of the 10 stamens, one of which is replaced by a staminode, while the other by one half of the anterior petal becoming antheroid (Figs. 2-*a* and 2-*b*). In *Cassia Fistula* staminodes occur frequently and how far these two changes noted here are correlated with the axillary floral prolification cannot be said with certainty. "Partially antheroid" (1 p. 299) petals are said to occur occasionally and that in double flowers like *Orchis mascula.*

Polyphylly. (in which members of any particular whorl are increased in number).

Polyphylly of all the floral whorls has been met with in Cassia fistula.

(a) Polyphylly of the Calyx. Only one case has been met with where the number has been increased to seven and this was accompanied by the number of the other parts of the flower being proportionately increased. In this flower the numbers of the parts were:

Corolla	7	Stamens.	21
Calyx	7.	Carpels	7.

(b) Polyphylly of the Corolla. Two cases have been noted (besides the one previously mentioned). In one, it is unconnected with similar alteration in the calyx or stamens. In this, there were six petals, ten stamens, five sepals and a normal monocarpellary ovary. In the other, there were 7 petals and 12 stamens, there being no change either in the calyx or in gynoecium. Only in Trifolium in Leguminoseæ has this been recorded.

(c) Polyphylly of the Androecium. Besides the flowers described in (*a*) and (*b*) another flower was met with (Fig. 3) in which there were 12 stamens, and this increased number was not accompanied by any corresponding alteration in other whorls. Associated with this is the petalody of one of the stamens. It is curious that only the anther has become petaloid, while the filament has not undergone any such change.

(*d*) *Polyphylly of Gynoecium.* (Fig. 4). This is of rather frequent occurrence. Of the 220 flowers that were examined, about 28 showed this phenomenon. The carpel numbers were generally 2, 3, 4, 5 or 7. Except in one case where the number of carpels was 7 as noted in (*a*) in all other cases, the increase in the number of carpels was not associated with any corresponding increase in the other floral parts.

Discussion. The occurrence of bicarpellary pistil has been recorded in the closely allied genus Saraca by Krishnamurti,[3] though the term polyphylly is not applied by him. Rendle,[4] says in connection with the pistil of the Leguminoseæ; "Departures from a monocarpellary pistil are rare. Tounatea dicarpa (Caesalpinoideæ) has two carpels, while in several genera of the tribe Ingeæ (Mimosoideæ) there are more than one." Thus no mention has been made of the genus Cassia. The frequent occurrence of a polycarpellary gynoecium in a typically monocarpellary family can only be interpreted as a case of reversion, indicating the true Rosaceous ancestry of the Leguminoseæ. In fact the single carpel in the Pruneae is often regarded as leading on to the Leguminoseæ. Besides this, the other abnormalities such as polyphylly of the other floral whorls, petalody, staminody, etc., seem to throw some light upon the relationship of the Leguminoseæ with the Polycarpicae. The relative primitiveness of the latter has been maintained by Arber and Parkin[5] and recently supported by Hutchinson[6] and others. Among other characters the following are some which determine the primitive position of the Polycarpicae:—(a) The spiral arrangement of the numerous floral members on an elongated floral axis. (b) Apocarpous carpels. (c) Sharp distinction between calyx and corolla may be wanting. (d) The ease with which stamens are transformed into staminodes or petals. The occurrence of most of these which are primarily to be regarded as cases of reversion, seems to establish the connection of the Leguminoseæ with the Polycarpicae. Thus the "abnormalities" herein recorded seem to lend support to the view that the Leguminoseæ have been evolved from a Polycarpiceous ancestry, through the Rosaceæ as the intermediate stage.

3. Krishnamurti (1931): A note on the occurrence of bicapellary pistils in the flowers of *Saraca indica*. Jour. Ind. Bot. Soc., Vol. 10, p. 159.

4. Rendle (1925): The classification of flowering plants, Vol. II, p. 359.

5. Arber and Parkin (1907): On the origin of Angiosperms. Jour. Linn. Soc., London, Vol. 38, p. 29.

6. Hutchinson (1926): The families of flowering plants. London.

Magnetic Susceptibility of Sulphur and some Sulphur Compounds

BY

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1. INTRODUCTION.

A thorough study of many sulphur compounds was originally done by Pascal.[1] A few compounds of sulphur were also studied by Farquharson[2] with the Curie-Cheneveau balance. He compared the experimental values obtained with the theoretical estimates based on the calculation of Angus[3] and found that the difference was a paramagnetic term of about the same order of magnitude as the calculated paramagnetic term for the hydrogen molecule. Kido[4] has also derived experimentally the susceptibilities of several incomplete ions of sulphur and noted a consistent divergence between his values and the theoretical figures of Angus. It was found that the paramagnetic component in the susceptibility of the ions increased in magnitude as the number of valency increased. A graph drawn between the ionic susceptibilities and number of valency of ions gave a straight line passing also through the value for atomic sulphur.

It is shown in another paper* that sulphuric acid-water mixtures show slight deviations from additivity. A maximum in the susceptibility was obtained at the concentration corresponding to $2H_2SO_4,H_2O$. It is reasonable to assume that when the ionic susceptibility is maximum the ions exist in the freest state. Hence the value of the SO_4^{--} has been calculated from the value of the susceptibility at this concentration. This enables us to determine the ionic susceptibilities of different cations with which it is in combination.

In the choice of the salts some have been taken with water of crystallisation. The susceptibility of the anhydrous salt has been calculated assuming the validity of the additive law of molecular susceptibilities.

* Under publication.

1. Comp. Rend., 3, 145, 1921.
2. Phil. Mag., 14, 1003, 1932.
3. Proc. Roy. Soc., 130, 573, 1932.
4. Tohoku Imp. Uny., Sci. Rep. 22, 835, 1933.

This procedure is justified in view of the fact that it has been shown that the decahydrate of sodium sulphate does not show any change in value when the crystal is heated to over 33° at which temperature it is known to dissociate into the anhydrous salt and water. A concentrated solution of the salt in water also failed to indicate any changes in susceptibility on heating to over 33°C. This at once indicates that in the hydrated salts normally, the binding between the salt and the water molecule is loose and this does not affect the magnetic susceptibility to any measurable extent. This case in fact, is one where a change might be expected since the hydrate is proved to exist even in solution and there is a definite transition point. The difference between a hydrate in solution and in the solid state lies in this that while in the former type a linkage very like a chemical bond is involved, in the latter case, crystalline forces play an important role in binding the water molecules to the solute molecules. That water of crystallisation might be present in the solid state without involving any chemical linkages is proved by the fact that the inert gases, which are incapable of combining with other molecules, do crystallise out with water of crystallisation, at very low temperatures.

The foregoing considerations show that the assumption of the validity of the additive law of molecular susceptibility is valid in the case of the hydrated salts. Ray Chaudhuri[5] however, investigating the hydrated and non-hydrated salts finds that the additive law is not obeyed. He observes a large decrease from the additive value and the decrease is greater, the greater the heat of formation of the compound. Such a result seems to be doubtful in the light of the foregoing considerations. Besides the mixtures, stannic chloride-acetic acid and stannic chloride-ethyl formate investigated by Kido[6] do not show any changes from additivity despite the fact that in both the mixtures compounds are formed attended with a large evolution of heat.

These considerations point out clearly the justification for the calculation of the susceptibility value of the anhydrous salt from that of the hydrated salt. The ionic susceptibility is then calculated by assuming the susceptibility of -38.89 for the SO_4^{-}ion.* One of the aims of this paper is to show that the ionic values calculated with these assumptions are in good agreement with the values obtained by Kido from solution or non-hydrated salts and by Hocart[7] from solution.

5. Zeits f. physik, 1932, 77, 271.
6. Tohoku Imp. Uni., Sci. Rep., 21, 385, 1932.

* The value has been taken from the paper under publication.

7. Comp. Rend., 188, 1151, 1929.

Sulphur is well known to exist as a sexivalent ion in sulphuric acid and the sulphates. The susceptibility value of the bivalent ion has also been estimated from measurements on carbon-disulphide. In view of the high purity with which this liquid is available the value of the susceptibility determined may be taken to be precise. Measurements have also been attempted on sodium and potassium sulphides ; but since the actual composition of the substances used is a matter of some doubt no ionic values have been deduced therefrom. It may be mentioned that so far no measurements seem to have been made of the alkaline sulphides.

A study has also been made of the different allotropic modifications of sulphur. Rhombic and monoclinic varieties of sulphur have been studied by Bhatnagar and Mathur.[8] Their result is in general confirmed. The γ sulphur or the plastic variety has also been prepared and the susceptibility determined. The change of susceptibility when the plastic type is converted into the rhombic form has also been investigated.

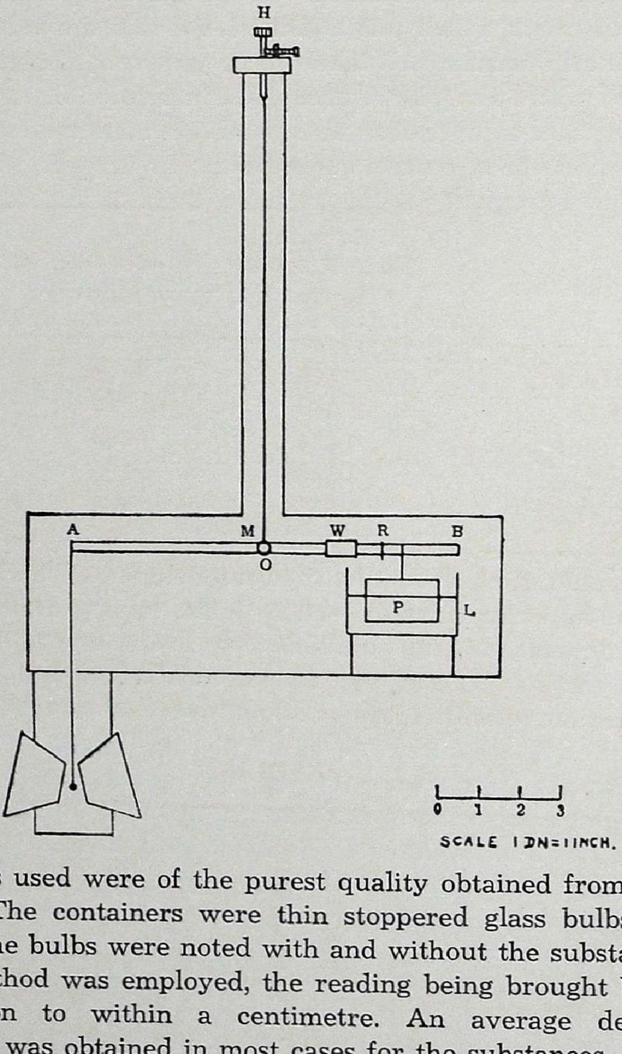
2. EXPERIMENT.

Measurements of susceptibility were made with a Curie balance. Fig. 1 shows the experimental arrangement used. AB is a light aluminium strip suspended by means of a fine copper wire No. 40 S.W.G. The wire is fixed at the top to a torsion head H by which delicate adjustments during retorsion could be made. At the end A the test bulb is suspended by a silk fibre. A counterpoising weight W and a smaller rider R are placed on the arm OB. By adjusting their positions the beam could be made exactly horizontal and small up and down movements to the test bulb could be given by altering the position of the rider. P is a plate attached to the arm OB and dipping in some oil contained in a glass basin L. A concave mirror M of focal length one metre is fixed at O. The arm and the suspension wire were enclosed in a wooden case with glass front to prevent air currents from disturbing the balance during observations. By adjusting a lamp and scale a circular spot of light with a vertical wire was obtained on the transparent scale.

Determination of the position at which the magnetomotive force on the test bulb was maximum was obtained by studying the deflections along the line of symmetry between the pole pieces. At the place where the force was maximum, investigations were also made in a vertical direction. The region where this force was maximum was then defi-

8. Phil. Mag., 8, 1041, 1929.

nitely fixed. The angle between the pole faces was so arranged that a flat maximum was obtained in the horizontal direction.



The salts used were of the purest quality obtained from Kahlbaum or Merck. The containers were thin stoppered glass bulbs. The deflections of the bulbs were noted with and without the substances. The retorsion method was employed, the reading being brought back to the same position to within a centimetre. An average deflection of about 10 cm. was obtained in most cases for the substances. The value of the mass susceptibility of each substance as derived from the different observations on the substance agreed to within ½ per cent.

The magnet was a large one of Pye's type capable of carrying 16 amperes. The readings were taken at a current strength of 5 amperes.

The standard substance used was water the diamagnetic susceptibility of which was assumed to be 0·72.**

** In this paper all the susceptibility values must be multiplied by 10^{-6}.

The substances were weighed with an accurate Sauter's balance, the error in the masses determined being 0·1 milligram.

3. RESULTS.

(*a*) *Sulphates.* The results obtained for a few sulphates are tabulated below :—

TABLE I.

Substance.	Mass susceptibility.	Molecular susceptibility.	Molecular susceptibility of anhydrous salt.
$2H_2SO_4,H_2O$*	0·424	90·74	(38·89)
Li_2SO_4,H_2O	0·428	54·75	41·79
Na_2SO_4 (anhydrous)	0·324	46·03	46·03
K_2SO_4 ,,	0·384	66·92	66·92
Mg $SO_4,7H_2O$	0·555	136·8	46·08

The value of 38·89 for the diamagnetic susceptibility of SO_4^{--} ion is found to agree remarkably well with the value of 39 obtained by Kido and Farquharson. Using this value the ionic diamagnetic susceptibilities of Li^+, Na^+, K^+, and Mg^{++} have been calculated. The results obtained here along with those of other investigators are given below :—

TABLE II.

Ion.	Angus (Theory)	Joos[9]	Pascal & Pauling[10]	Kido	Ikenmeyer[11]	Pascal[12]	Author
Li^+	0·665	1·3	0·2	1·6	4·0	4·2	2·90
Na^+	3·74	6·5	5·2	7·6	10·4	10·2	7·14
K^+	13·06	14·5	14·5	13·6	16·0	18·5	14·02
Mg^{++}	2·89	—	—	4·3	4·5	10·1	7·19

* Loc cit.

9. Zeits. f. physik, 19, 347, 1923.
10. Proc. Roy. Soc., 114, 181, 1927.
11. Ann. Der Physik, 1, 169, 1929.
12. Comp. Rend., 158, 37, 1914 ; 159, 429, 1914 ; 173, 144, 1921.

It will be noted that the results obtained by the author are in good agreement with those of other investigators particularly when mutual agreement among the values given by them is not very striking. In fact the author's values come almost midway between those of Ikenmeyer and of Joos. It should also be remembered that the results of Ikenmeyer were obtained for the alkali halides in solution. Van Vleck has pointed out that the molecular susceptibility for an inert gas should be intermediate between those of the corresponding halogen and alkali ions which should be respectively greater and smaller. However, it is seen from the table that the values given by any particular author do not conform to this rule.

It will be seen from the foregoing conclusions that the ionic susceptibilities of the alkali ions calculated from hydrated salts agree with those obtained from experiments with solutions or dehydrated salts. This confirms the conclusions reached earlier and justifies the assumptions made in the calculation of the ionic susceptibilities.

(b) *Sulphides.* The diamagnetic susceptibility of carbon disulphide was found to be 0·565 and the molecular susceptibility works to 43·01. The value given in the International Critical Tables is 0·54 giving a molecular susceptibility of 41·1 and Kido's calculated value would be 47·4. If we accept the susceptibility value of + 7·4 for C^{+4} we should get for S^{-2} the value − 25·2. Similarly if the diamagnetic susceptibility value of O^{-2} is taken as 13·7, the ionic susceptibility of S^{+6} as calculated from the susceptibility of the SO_4^{--} ion works to + 15·91. The specific diamagnetic susceptibilities of Na_2S, $9H_2O$ and K_2S were found to be 0·614 and 0·362 respectively.

(c) *Allotropic modifications of sulphur.* A large quantity of powdered sulphur was dissolved in pure carbon disulphide and the liquid allowed to evaporate. Rhombic sulphur crystallised out in orthorhombic pyramids.

Powdered sulphur was molten in a crucible and then allowed to solidify. When the mass had partially solidified the still liquid portion was poured off. Thus prismatic needles of sulphur of the monoclinic variety were obtained.

Plastic sulphur was prepared by pouring boiling sulphur in a thin stream into cold water. A tough elastic material was obtained and it was dried between filter paper. It was then kept inside a desiccator and exhausted to remove all water.

It is well known that the plastic variety passes slowly into the rhombic form in the course of a few days. This change can be brought about within a short time by melting the mass. In the experiments readings were taken with the plastic form and bulbs were heated to about 120°C and cooled. The deflections were again noted. This indicated changes in susceptibility if any and thus provides one with a sure test for examining whether the amorphous and the crystalline varieties have different values.

TABLE III.

Form.	Author χ	Bhatnagar & Mathur. χ	Owen. χ
Rhombic	0·481	0·487	0·485
Monoclinic	0·469	0·462	—
Plastic	0·473	less than 0·487	—
Plastic after heating.	0·480	—	—

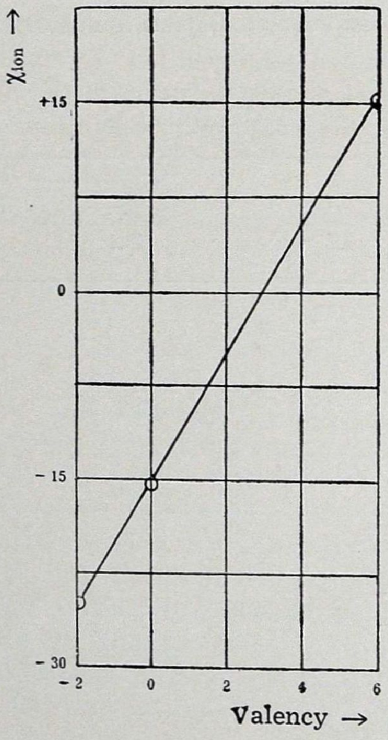
From the table it is seen that there is qualitative agreement between the results of Bhatnagar and Mathur and the author. The plastic form on heating gains in susceptibility and attains the value of the rhombic variety. The diamagnetic susceptibility value of plastic sulphur indicates that the so-called plastic sulphur may be a mixture of the rhombic and the monoclinic varieties.

It is well known that in the case of metals the allotropic modifications of any metal have different susceptibilities. In the case of tin, for example, it is known that white tin is paramagnetic while grey tin is strongly diamagnetic. A large difference in susceptibility exists between the two allotropic modifications of phosphorus though it is a non metal. The white form has a diamagnetic susceptibility of 0·9 while the red form has a value of only 0·67.

In the table are collected the values for the different ions of sulphur.

Ion.	Angus.	Kido.	Author.
S^{+6}	+ 1·31	+ 15·0	+ 15·4
S^{0}	—	− 16·0	− 15·4
S^{-2}	− 32·63	− 27·4	− 25·2

It is seen from the table that there is a large departure from the theoretical value especially for the higher valency. However, the points plot themselves on a straight line as indicated in the accompanying figure.



4. SUMMARY AND CONCLUSION.

(*a*) The diamagnetic susceptibilities of crystalline sulphates of Li, Na, K, Mg have been determined from the solid state by the Curie balance. The ionic susceptibility of Li^+, K^+, Na^+, and Mg^{++} calculated from the magnetic values of the hydrated salts assuming the additive law agree reasonably well with the values of other investigators. This shows that the nature of the bond between the water molecules and the sulphate ion is a loose one and does not influence the susceptibility of the molecule appreciably. The values of the susceptibility for some sulphides have been determined. (*b*) The allotropic modifications of sulphur have also been investigated magnetically. A small difference is noted between the values of the rhombic and monoclinic varieties. Plastic sulphur gives an intermediate value which rises up to the value for the rhombic

form when heated to 120°C and cooled. It is thus likely that the so-called plastic variety is a combination of the other two modifications. (c) A graph drawn between the susceptibility of different incomplete sulphur ions and the valency of sulphur gives a straight line, thus confirming Kido's result.

In conclusion, I take this opportunity to thank Dr. S. Ramachandra Rao, for his keen interest and continued help throughout the course of this investigation. My thanks are also due to the authorities of the Annamalai University for the award of a studentship.

The Gastric Armature of some South Indian Decapod Crustacea

BY

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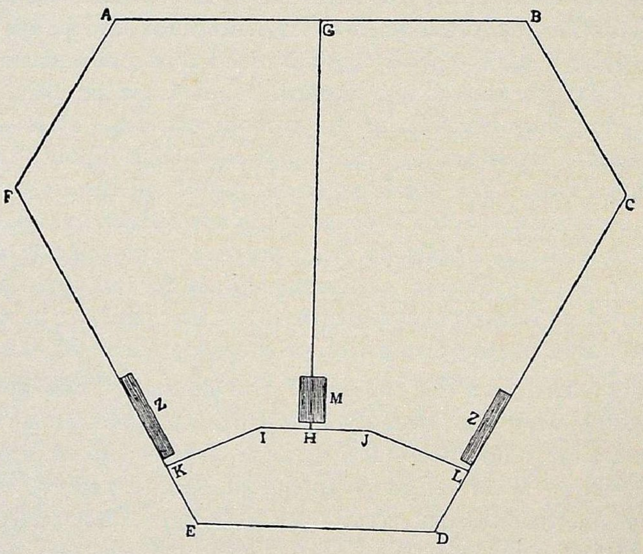
INTRODUCTION

The gastric armature of decapods is a very complicated mechanism which varies in its structural details in the different genera. Its structure in some of the European forms *viz., Cerataspis monstrosus, Nephrops norwegicus, Astacus fluviatus, Cancer pagurus, Stenorhyncus* and *Portunus,* has been dealt with by Bonier, Meek (6) Huxley (3), Pearson (8), Mocquard (7) and Vitzou (11) respectively. But very little attention seems to have been paid to its study in the Indian forms. The present paper deals with a comparative account of the gastric armature in the following South Indian forms :—

1. *Gelasimus annulipes,* Latreille.
2. *Paratelphusa (Oziotelphusa) hyrodromus,* Herbst.
3. *Neptunus pelagicus,* (Linnaeus).
4. *N. sanguinolentus,* Herbst.
5. *Matuta victor,* Fabricius.
6. *Albunea symnista,* (Linnaeus).
7. *Diogenes custos,* Fabricious.
8. *Diogenes diogenes,* Herbst.
9. *Clibanarius longitarsis,* de Haan.
10. *C. olivaceus,* Henderson.
11. *C. acquabites,* Dana.
12. *C. arethusa* De Man.
13. *C. infraspinctus,* Hilgendat.
14. *Penaeus indicus,* Milne-Edwards.

In all these forms the mechanism of the gastric armature is fundamentally similar. It is divisible into two main parts, namely (1) a masticatory apparatus composed of a hexagonal arrangement of thickly chitinised sclerites bearing sharp teeth and (2) a straining apparatus constituted by *(a)* the complicated arrangement of profuse setae carried by the pectinal system of ossicles, (*b*) the ampullary, inter-ampullary

and supra-ampullary ridges present in the pyloric lumen and *(c)* the cardio-pyloric valve. The straining devices are mostly concentrated in the pyloric division, whereas the masticatory structures are mainly confined to the cardiac division. The masticatory sclerites are formed by the thickening and calcification of certain regions in the chitinous lining of the foregut and are worked by a system of anterior and posterior gastric musculature. The following are the main sclerites and their relative positions are diagrammatically represented in Text—fig. 1.



TEXT FIG. 1. Schematic representation of the relative arrangement of the ossicles of the gastric armature. A.B. Meso-cardiac ossicle ; A.F. Ptero-cardiac ossicle ; B.C. Ptero-cardiac ossicle ; C.D. Zygo-cardiac ossicle ; D.E. Pyloric ossicle ; E.F. Zygo-cardiac ossicle ; G.H. Uro-cardiac ossicle ; I.J. Pro-pyloric ossicle ; K.J. Exo-pyloric ossicle ; L.J. Exo-pyloric ossicle ; M. Median tooth ; Z. Zygo-cardiac or later teeth.

(i) The mesocardiac ossicle,
(ii) A pair of pterocardiac ossicles,
(iii) A pair of zygocardiac ossicles bearing the lateral teeth,
(iv) The pyloric ossicle bearing a denticle,
(v) A pair of exoplyoric ossicles,
(vi) The propyloric ossicle,
(vii) The urocardiac ossicle bearing the median tooth.

In the cardiac and the pyloric chambers, besides these main ossicles, constituting the gastric armature proper, there are a set of ossicles—

"the supporting ossicles"—which give attachment to the muscles of the foregut. In most cases these "supporting ossicles" of the cardiac chamber are variously modified and constitute an efficient straining mechanism.

The *modus operandi* of the armature is interesting. It represents a complicated system of seven levers of the second order whose mechanical constitution resolves the force of a single straight pull, resulting from the contraction of the anterior or posterior gastric muscles, into four convergent forces acting at many points. The lines of action of these four forces are along (*a*) the urocardiac ossicle with its median tooth, (*b*) the two zygocardiac ossicles with their lateral teeth and (*c*) along the pyloric ossicle with its chitinised and pointed anterior end, which can be regarded as the ventral tooth from its relative ventral position during the operation of the various ossicles. It is the collision of these four teeth-bearing ossicles that brings about the efficient mastication of food. The crushing power produced by the collision is so great that even the hard shells of molluscs are reduced to minute pieces. The resistance of the cardio-pyloric constrictor muscles is mainly responsible for the restoration of the armature to its original condition. The mode of working of the gastric armature differs in the various forms, depending on the disposition of the propyloric ossicle.

The structure and disposition of the median tooth and the urocardiac ossicle vary considerably. The arrangement of setae is in no two cases similar. The pectinal system of ossicles shows different kinds of modifications. With reference to the shape and nature, the denticles carried by the masticatory structures also vary. The gastric musculature exhibits slight variation. The variations are apparently correlated with the nature of the food of the animal.

THE GASTRIC ARMATURE OF *GELASIMUS ANNULIPES*, LATR.

The Mechanism of Mastication :—It is composed of two distinct sets of ossicles, namely, the ossicles of the cardiac chamber and the ossicles of the pyloric chamber. The ossicles of each chamber form two definite categories, namely, the main ossicles and the supporting ossicles.

The cardiac division of the stomach is a simple spherical and spacious chamber exhibiting a number of thickenings in its cuticular lining. The ventral surface of the cardiac chamber is invaginated posteriorly giving rise to the cardio-pyloric valve which separates the cardiac chamber from the pyloric.

The mesocardiac ossicle is a triangular piece of sclerite transversely placed in the anterior region of the dorsal wall of the

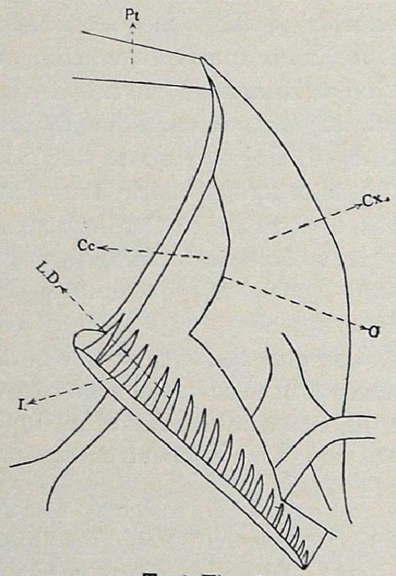
cardiac chamber. Its broader end is posteriorly directed and is not distinctly separated from the urocardiac ossicle and from the pterocardiac ossicles. The posterior end curves dorsally as well as ventrally and serves for the attachment of the cardio-pyloric constrictor muscles.

The urocardiac ossicle is attached to the hind end of the mesocardiac ossicle and projects posteriorly along the dorsomedian line. It exhibits posteriorly a ventral inclination, and on reaching the cardio-pyloric passage, gives articulation to the anterior extremity of the propyloric ossicle. Just in front of this articulation it bears ventrally the large median tooth. The ossicle as well as the tooth show five to six transverse ridges with intervening concavities. Running at right angles to these, is a longitudinal ridge. In *Cerataspis monstrosus,* described by Bonier, the median tooth is simple, short, recurved and not carried on any specialised structure like the urocardiac ossicle. Further it does not show any differentiation in its structure. In *Nephrops norwegicus* and *Astacus fluviatus* it is borne at the posterior extremity of the urocardiac ossicle, but in the former it is a conical structure and in the latter is triradiate. In *Cancer pagurus,* Pearson (8) describes it as a large and blunt structure.

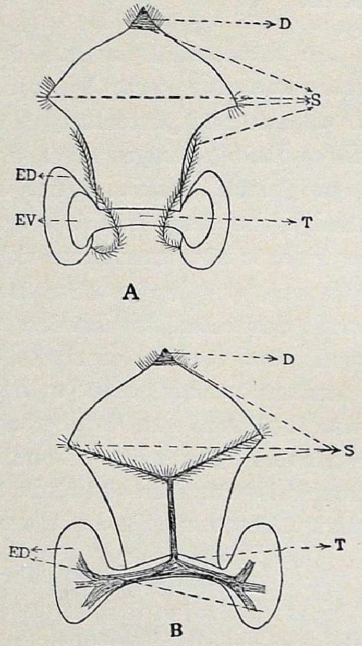
The pterocardiac ossicles are a pair of ossicles attached to the meoscardiac ossicle on either side by means of oblique hinges. Their inner ends which are in contact with the mesocardiac ossicle are broader and taper towards their outer extremities. The anterior gastric muscle bands are attached to the inner, broader ends of the pterocardiac ossicles. The outer extremities of each pterocardiac ossicle articulate with the zygocardiac ossicle by means of a ligament which Pearson (8) describes as the antero-lateral ligament. The posterior border of the pterocardiac ossicles is straight, but the anterior is slightly curved.

The zygocardiac ossicles are a pair of lateral ossicles articulating with the outer ends of the pterocardiac ossicles on either side. They pass posteriorly showing a marked ventral inclination as they proceed. The posterior extremity articulates with the exopyloric ossicle which is attached to the propyloric ossicle, thereby connecting the pyloric region with the cardiac. They are narrow at their anterior attachment, attaining their maximum breadth at the place where the lateral teeth are given off. The inner border is curved ventrally whereas the outer margin is bent inwards, so that the ossicle presents a concavity towards the inside and a convexity towards the outside. The outer border of the ossicle is folded resulting in a deep groove immediately below the outer convexity. Though the

ossicle is in reality thin, yet by means of this complicated folding it creates a false impression of thickness. The ridges and the denticles carried by the inner border of this zygocardiac ossicles form the lateral



Text Fig. 2.



Text Fig. 3.

TEXT FIG. 2. The Zygo-cardiac ossicle and the lateral tooth of Gelasimus annulipes, Latr. Cc. Concavity; Cx. Convexity; I. Inner border; L.D. Denticles of the lateral tooth; O. Outer border; Pt. Ptero-cardiac ossicle.

TEXT FIG. 3. The pyloric ossicle of Gelasimus annulipes, Latr. A. Ventral view; B. Dorsal view; D. Denticle; E.D. Dorsal extension; E.V. Ventral extension; S. Setae; T. The transverse, chitinous bar-like structure.

teeth. The dorsal or outer border of the ossicle is entirely beyond the field of action of the masticatory sclerites. The posterior border is in continuation with the exopyloric ossicles.

The lateral teeth are formed by the anterior and inner borders of the zygocardiac ossicles and consist of a number of ridges and denticles. They lie on either side of the median tooth at the cardio-pyloric entrance. On each lateral tooth there are a number of very short denticles which are very closely set. The pointed ends of these denticles project freely as the teeth of a comb and probably during the process of mastication they fit into the concavities which intervene the

transverse continous ridges on the median tooth and urocardiac ossicle. All the denticles are of uniform structure and become gradually short as they proceed from the posterior to the anterior end.

In the case of *Cerataspis montrosus* the lateral teeth are represented by longitudinal rows of cuticular thickenings of the lateral folds of the gastric chamber. In the *Astacus fluviatus* and *Nephrops norwegicus* they are not so specialised. In *Cancer pagurus* there is a single large denticle anteriorly, which is followed by seven smaller denticles, and the folded inner edge of the zygocardiac ossicle is traversed by as many as twenty-four transverse ridges.

The cardiac ossicles, in general, resemble those of *Cancer pagurus*. They mainly contribute to the constitution of the complicated straining devices.

The pyloric chamber is comparatively smaller in size and the posterior part of its cavity is very much reduced by the thickening of its ventral chitinous lining into the pyloric ampullae, whereas the anterior part, about a fourth of the whole chamber, is free and spacious. When the foregut is dissected, two swellings become conspicuous ventrally in the gastric region. These indicate the ampullary zone of the pyloric chamber.

A pair of ampullary ridges occupy the posterior three-fourths of the pyloric region. The chitinous lining of the ampullae is produced into a number of parallel, longitudinal ridges which are profusely beset with setae. These setae are so situated that their free ends are opposed to the direction of the food passage and they are profusely branched. According to Vitzou (11), the setae occurring in the gastric region are not true setae, having no central cavity characteristic of the true setae, but are simply cuticular extensions.

The floor of the chamber along the mid-ventral line is raised into a ridge, the inter-ampullary ridge, on either side of which, and in close contact with, are two pyloric ampullae.

Immediately above the pyloric ampullae along the ventro-lateral line, the wall of the pyloric chamber is produced into a pad like structure on each side. These are also profusely supplied with long setae. These are the supra-ampullary ridges. They extend so far as to meet in the middle line thus marking out a partially separated ventral and dorsal regions in the pyloric lumen. The ventral region between the supra-ampullary ridges and the pyloric ampullae is further subdivided into two equal and similar parts by the development of the inter-ampullary ridge along the mid-ventral line of

the floor of the pyloric chamber. The dorsal division of the posterior three-fourths of the pyloric region is fairly spacious.

The anterior one-fourth of the pyloric chamber is in free communication with the posterior dorsal division, whereas the communication between the posterior ventral division and the anterior region is very much restricted by the ampullary ridges and the profuse setae projecting from them into the very narrow, ventral region of the pyloric lumen.

The exopyloric ossicles are a pair of sclerites which are situated on either side of the posterior extremity of the propyloric ossicle and in articulation with it. Each is triangular in shape, the base being in contact with the posterior border of the zygocardiac ossicle, while the apex articulates with the posterior border of the propyloric ossicle.

The propyloric ossicle is roughly triangular in shape and attached by means of its narrow anterior border to the posterior extremity of the urocardiac ossicle immediately below the attachment of the median tooth. The broader hind end gives articulation to the exopyloric ossicles on either side. The ossicle is considerably depressed in the centre. Its hind border is entire and not bifurcated as in the case of *Cancer pagurus*. The ossicle is fairly well calcified both in the centre and at the periphery and not membraneous as in the case of *Cancer*. The cardio-pyloric muscles extend between the posterior border of the ossicle and the mesocardiac ossicle.

The pyloric ossicle lies in the mid-dorsal line in the pyloric chamber. It occupies completely the anterior one-fourth of the pyloric region. The central portion of the ossicle is not so well calcified as the margins. The anterior extremity is pointed and thickly calcified and produced into a denticle which may be called the ventral tooth. On either side of this denticle can be discerned tufts of setae. Posteriorly the margin is calcified to form a transverse bar. This transverse bar on either side is produced into a dorsal and a ventral extension. The dorsal one is broader than the ventral and is attached to the hind end of the subdentary ossicle of its side. The ventral extension is attached to the posterior ends of the post-pectinal and the infero-lateral-cardiac ossicles of its side. The pyloric ossicle appears as if it were suspended by these three pairs of cradiac supporting ossicles.

In the case of *Cerataspis monstrosus* the pyloric region is not differentiated into definite ossicles. In *Astacus fluviatus* the structure

and relative arrangement of these is entirely different. The subdentary ossicles are immovably attached on either side of the pyloric ossicle, and the propyloric shows bifurcation. In *Cancer pagurus* the pyloric ossicle is membranous in the centre and is calcified laterally showing the paired nature of its origin.

The pyloric supporting ossicles are not in any way concerned with the straining mechanism of the armature. The position and structure of these ossicles are similar to those of *Cancer pagurus* a detailed account of which was given by Pearson (8).

The Mechanism of Straining:—The straining apparatus or filter is constituted by (*i*) six pairs of setose cardiac supporting ossicles, namely:—

(*a*) a pair of pre-pectinal ossicles,
(*b*) a pair of pectinal ossicles,
(*c*) a pair of post-pectinal ossicles,
(*d*) a pair of lateral cardio-pyloric ossicles,
(*e*) a pair of infra-lateral cardiac ossicles, and
(*f*) a pair of subdentary ossicles,

and by (*ii*) the setose, parallel longitudinal ridges of the ampullary, inter-ampullary and supra-ampullary folds of the pyloric lumen.

Each pre-pectinal ossicle in its outline follows the inner curve of the zygocardiac ossicle of its side, and on reaching the position of the median tooth, is much broadened and attached to the funnel shaped pectinal ossicle. The broadened region is beset with setae. The inner border of the pectinal ossicle is produced into seven or eight, very short, chitinous denticles, the infra-lateral cardiac teeth. The two rows of infra-lateral cardiac teeth are on either side of the median tooth and parallel to it. During the operation of the armature, they evidently fit into the concavities intervening the transverse ridges on the median tooth, thus cleaning the median tooth.

The pectinal ossicle sends backwards a rod-like structure, the post-pectinal ossicle, which, at its posterior end, is attached to the ventral extension of the transverse pyloric bar. The entire course of the ossicle is beset with setae which are directed anteriorly. The pectinal ossicle is also attached to the lateral cardio-pyloric ossicle at its hind end. Posteriorly the lateral cardio-pyloric ossicle sends backwards a rod-like structure, the infra-lateral cardiac ossicle which lies parallel to the post-pectinal ossicle. It extends as far as the hind end of the post-pectinal ossicle and is also attached to the ventral

extension of the pyloric bar. There are long setae lining its entire course. It is dorsal in position to the post-pectinal ossicle, but ventral to the subdentary ossicle. Its upper end is in contact with the subdentary ossicle.

The subdentary ossicle is movably attached to the outer dorsal border of the zygocardiac ossicle anteriorly. Posteriorly it is broadened and supplied with numerous long setae, and finally attached to the dorsal extension of the transverse pyloric bar.

The setae on the ampullary, inter-ampullary and supra-ampullary ridges are directed anteriorly so as to oppose the food current. The spacious dorsal division of the pyloric lumen is capable of being completely separated from the ventral division by the approximation of the two supra-ampullary ridges. Further the membranes extending between the various ossicles are also supplied with setae. No such straining device is present in *Cerataspis monstrosus*. In *Astacus fluviatus*, *Nephrops norwegicus* and *Cancer pagurus* the arrangement is quite different.

The Musculature of the Gastric Armature:—It is divisible into two types, *viz.*, the extrinsic and intrinsic muscles. In the case of the extrinsic system the muscles run from the ossicles of the gastric armature inside the foregut to the skeletal system outside the foregut. In the case of the intrinsic muscles, they run between the different ossicles of the armature within the foregut itself.

The Extrinsic Musculature:—The anterior gastric muscles extend between the inner ends of the pterocardiac ossicles and the anterior region of the carapace. They are separated into two distinct bands. They diverge considerably as they proceed anteriorly.

There are three bands of posterior gastric muscles. The inner or the central band proceeds from the pyloric ossicle to the posterior region of the carapace. The outer bands proceed from the dorsal surface of the hind ends of the zygocardiac ossicles to the posterior region of the carapace.

The cardiac levator muscles are a pair of bands extending between the lateral walls of the cardiac chamber and the carapace. The pyloric levator muscles extend between the lateral walls of the pyloric chamber and the posterior region of the carapace. There is a pair of cardiac depressor muscles which extend between the ventro-lateral wall of the cardiac chamber and the anterior region of the sternum, the pyloric depressor muscles proceed ventrally from the ventro-lateral wall of the pyloric chamber.

The Instrinsic Musculature:—The cardio-pyloric constrictors are on the posterior of the mesocardiac ossicle and posteriorly on the posterior border of the propyloric ossicle. They are in three bands, the outer of which diverge slightly towards their insertion on the propyloric ossicle.

There are three pairs of lateral cardiac muscles. The dorsal pair extends between the dorsal border of the zygocardiac ossicle and the upper region of the infra-cardiac ossicle. The central pair extends between the upper region of the infra-cardiac ossicle and the prepectinal ossicle. The ventral pair extends from the lateral surface of the infra-lateral cardiac ossicle to the dorsal surface of the posterior lateral cardiac plate.

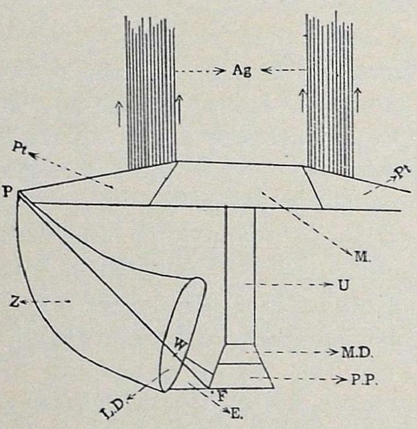
The cardiac constrictors are formed by two sets of muscles, the postero-lateral cardiac muscles and the antero-lateral cardiac muscles. The postero-inferior cardiac muscles extend between the two posterior ends of the infra-lateral cardiac ossicles. One end of the antero-lateral cardiac muscles is inserted on the anterior wall of the mesocardiac ossicle just above the insertion of the cardio-pyloric constrictor muscles, while the two divisions of the opposite, bifurcated end are attached separately to the anterior, lateral cardiac plate. Both these sets of muscles lie between the cardiac depressors and the cardiac elevators.

The pyloric constrictor muscles are in the form of a number of small bands extending from the postpectinal and infra-lateral cardiac ossicles to the supporting ossicles of the dorsal and lateral walls of the pyloric chamber.

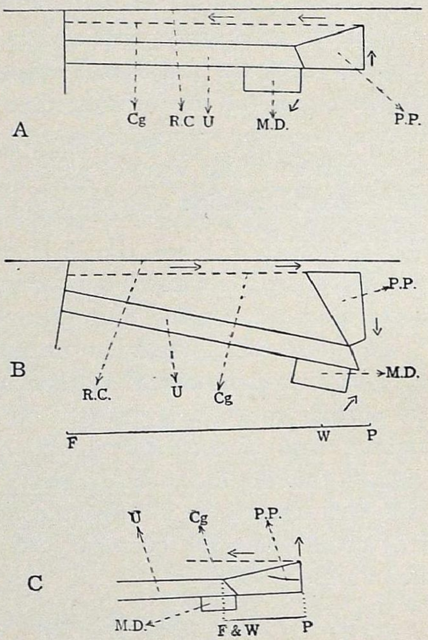
The modus operandi of the gastric armature:—The active movement of the armature seems to be entirely brought about by the anterior gastric muscles, as described by Mocquard (7) in the case of a living *Stenorhyncus* having a transparent carapace. Huxley (3), however, states that the operation is effected both by the anterior and the posterior gastric muscles in the case of *Astacus fluviatus.* As we shall see later on, the action seems to differ in different forms, depending mostly on the disposition of the propyloric ossicle in relation to the urocardiac ossicle.

When the anterior gastric muscles contract, some very striking changes are effected in the gastric armature. The pterocardiac ossicles are drawn forwards dragging along with them the mesocardiac and the urocardiac ossicles. The median tooth is also drawn forwards. The propyloric ossicle, when the armature is at rest, is in the same plane as the urocardiac ossicle, with its narrow anterior end articulating

with the hind end of the urocardiac ossicle, and the broader, hind end being posteriorly directed. When the mesocardiac ossicle is thrown forwards, the cardio-pyloric constrictor muscles pull the posterior border of the propyloric forwards, so that the propyloric ossicle assumes a



Text Fig. 4.



Text Fig. 5.

TEXT FIG. 4. The diagram to illustrate action of Zygo-cardiac ossicle of *Gelasimus annulipes*, Latr. Ag. Anterior gastric muscles; E. Exo-pyloric ossicle; F. Fulcrum; L.D. Lateral tooth; M. Meso-cardiac ossicle; M.D. Median tooth; P. Power; Pt. Ptero-cardiac ossicle; P.P. Pro-pyloric ossicle; U. Uro-cardiac ossicle; W. Weight; Z. Zygo-cardiac ossicle. The arrows indicate the direction of the action.

TEXT FIG. 5. Diagrammatic representation of the mode of action of uro-cardiac ossicle and pro-pyloric ossicle of *Gelasimus annulipes*, Latr. A. Position of the uro-cardiac and pro-pyloric ossicles at rest; B. Position of the same during action; C. Shows the action of pro-pyloric ossicle only; Cg. Cardio-pyloric constrictor muscles; F. Fulcrum; M.D. Median tooth; P. Power; P.P. Pro-pyloric ossicle; R.C. Roof of the Cardiac chamber; U. Uro-cardiac ossicle; W. Weight.

Arrows Indicate the direction of action.

vertical position. Owing to the presence of the roof of the cardiac chamber, the ossicle, while assuming a vertical position, presses downwards the posterior extremity of the urocardiac ossicle bearing the median tooth. Thus, as a result of the propyloric interference, a for-

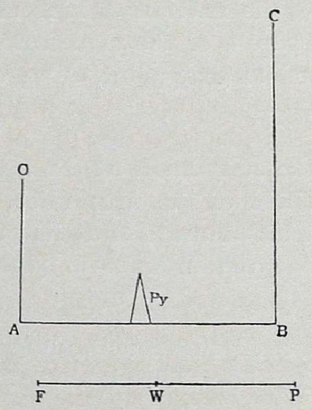
ward and downward movement is imparted to the median tooth, thus forcing it to collide with the zygocardiac ossicles bearing the lateral teeth. The downward movement of the median teeth would not be possible but for the propyloric mechanism. Both the urocardiac and propyloric ossicles represent levers of the second order. In the case of the urocardiac ossicle, the fulcrum is situated at its attachment with the mesocardiac ossicle. The power is applied at its hindermost extremity just behind the median tooth, by the anterior border of the pyloric ossicle. In fact, the power is the result of the contraction of the anterior gastric muscles, and transferred to that point. The work is done in the region of the median tooth.

In the case of the propyloric ossicle, the fulcrum is at the attachment of its anterior border with the hind end of the urocardiac, and power is applied by the cardio-pyloric constrictor muscles at its posterior border. Work is done at a point near the fulcrum in pressing down the median tooth.

The pterocardiac ossicles, in their forward movement, drag forwards with them the zygocardiac ossicles with their lateral teeth. Since the posterior border of the zygocardiac ossicles, just below the lateral teeth, is attached to the posterior border of the propyloric ossicle, the zygocardiacs are drawn upwards when the posterior border of the propyloric rotates upwards. The result is that a forward and upward movement is imparted to the lateral teeth, thus bringing them to collide with the median tooth which is forced downwards and forwards. Now if we consider the zygocardiac and exopyloric ossicles as one single piece we have a lever of the second order, the fulcrum being at the posterior end at the place of articulation of the exopyloric with the propyloric ossicle and the weight being in the region of the lateral tooth. The power is applied at the anterior end at its attachment to the pterocardiac ossicle. The power in this case also is due to the contraction of the anterior gastric muscle.

Simultaneously with this movement, there is the forward movement by the pyloric ossicle which is drawn forwards by the pectinal system of ossicles whose posterior ends are attached to the ventral extension of the pyloric, transverse chitinous bar. The fulcrum is at the anterior end of the subdentary ossicle which is attached to the posterior end of the zygocardiac ossicle dorsally. The posterior end of the subdentary ossicle is immovably attached to the dorsal extension of the pyloric bar. Work is done by the pyloric ossicle which is in between the two extensions. Thus by the contraction of the anterior gastric muscles, the four tooth-bearing ossicles are made to collide.

The original position is attained by these ossicles, partly by the relaxation of the anterior gastric muscle, and partly by the resistance of the posterior gastric and cardio-pyloric constrictor muscles.



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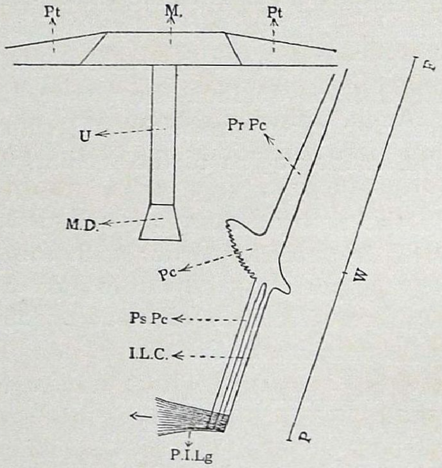


Text Fig. 7.

TEXT FIG. 6. To show the action of the pyloric ossicle of *Gelasimus annulipes*, Latr. A.B. The transverse chitinous, bar-like structure of the ossicle; B.C. Pectinal system of ossicles; D.A. Subdentary ossicle; F. Fulcrum; P. Power; Py. Pyloric ossicle; W. Weight.

TEXT FIG. 7. To illustrate the action of the pectinal system of ossicles carrying the infra-lateral cardiac teeth of *Gelasimus annulipes*, Latr. I.L.C. Infra-lateral cardiac ossicle; Pc. Pectinal ossicle; Pr.Pc. Pre-pectinal ossicle; Ps.Pc. post-pectinal ossicle; P.I.Lg. Posterior infra-lateral cardiac muscles. The rest of the lettering is as in Text Fig. 4.

The pectinal ossicles bearing the infra-lateral cardiac teeth do not seem to come into action during the play of the principal ossicles. During the action of the principal ossicles they are concerned only in drawing forward the pyloric ossicle. Their activity appears to commence just after the cessation of the activity of the main ossicles. When the armature is restored to its condition of rest, the postero-inferior cardiac muscles which are attached to the posterior borders of the infra-lateral cardiac ossicles contract. Since the post-pectinal ossicles are fused with the infra-lateral cardiac ossicles both at the posterior and anterior ends, the contraction of the above muscles draws together the pectinal ossicles, so that the infra-lateral cardiac teeth meet in the middle line just above the median tooth, brushing it as

they come together. The teeth clean the furrows of the median tooth and serve to keep the median tooth ready for the next action. The infra-lateral cardiac teeth are brought back to their original position by a contraction of the lateral cardiac system of muscles which extend between the dorsal border of the zygocardiac ossicles and the anterior region of the infra-lateral cardiac ossicles.

If we consider the pectinal and the infra-lateral cardiac ossicles as one single piece, we have again a lever of the second order, the fulcrum being at the anterior extremity of the pre-pectinal ossicle at its articulation with the outer end of the pterocardiac ossicle. The work is turned out in the region of the infra-lateral cardiac teeth, while power is applied by the postero-inferior cardiac muscles at the hind ends of the ossicles. Thus the entire operation falls into two distinct types. (1) The action of the main system of ossicles, and (2) the action of the supporting system of ossicles. The two actions alternate. The former is concerned with the crushing of the hard food materials, while the latter is concerned with the clearing away of the crushed material from the furrow of the main teeth-bearing ossicles, thus preparing them for the next action. The first action is effected mostly by the extrinsic system of muscles, while the second one is brought about entirely by the intrinsic muscles.

Pearson (8) suggests that, in *Cancer pagurus,* the separation between the soft nutritious parts and the hard shell-like structures belonging to animals taken in as food is effected to a certain extent in the anterior spacious division of the pyloric chamber. In *Gelasimus annulipes* the concrescence of the supra-ampullary ridges effects complete separation of the dorsal and ventral regions of the posterior pyloric chamber. Owing to the resistance offered by the profuse setae present on the ampullary ridges in the ventral division, the bigger hard pieces are forced into the dorsal division, whereas only very minute soft food material passes through the ventral division. There are some flap-like structures projecting backwards from the hind end of the dorsal division of the posterior pyloric lumen. Huxley (3) and Mocquard (7) suggest that these flap-like structures act as valves in preventing the contents of the mid-gut from passing into the fore-gut ; but Pearson (8) and Cuenot (2) state that these structures are concerned in carrying the hard shell-like pieces from the dorsal division directly into the hind gut. Thus the mid-gut which is without any chitinous lining suffers no risk or damage. The minute soft food material which is sieved through the setae present in the ventral division of the pyloric lumen, comes into contact with the secretions of the digestive glands at the posterior end of this region just above its entrance into the mid-gut.

THE GASTRIC ARMATURE OF *PARATELPHUSA (OZIOTELPHUSA) HYDRODROMUS* (HERBST).

The Mechanism of Mastication:—The cardiac chamber is constructed like that of *Gelasimus*; but the ossicles vary in structure.

The mesocardiac ossicle resembles that of *Gelasimus*. There is a slight constriction in the centre and the anterior end is ventrally inclined.

The urocardiac ossicle shows no deviation but the median tooth is different. It is differentiated into three regions. There is an anterior crescentic denticle and a much broader posterior denticle with a concavity between them. In front of the anterior denticle there is a semi-circular depression in the centre of which is situated a minute sharp denticle.

The pterocardiac ossicles resemble those of *Gelasimus*.

Each of the zygocardiac ossicles ends anteriorly in two knob-like structures, the inner of which is attached to the outer end of the ptero-cardiac ossicles. The outer ones are attached to the anterior ends of the prepectinal ossicles. The ossicles are very narrow and rod-like at their anterior ends, becoming gradually broad towards their hind ends. On reaching the position of the median tooth they give rise to the highly chitinised lateral teeth. Posteriorly the dorsal border of the ossicles articulates with the exopyloric ossicles.

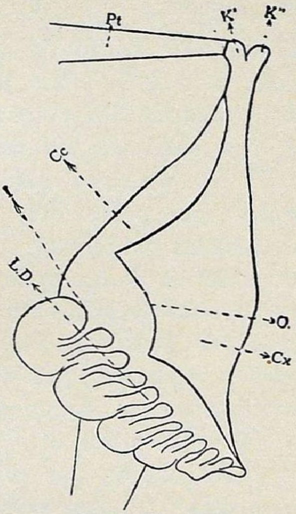
Each lateral tooth carries eight or nine hard denticles with intervening concavities. The entire denticulated region falls into three or four main lobes, the denticles on them being of different types varying in shape and sharpness.

The cardiac supporting ossicles and the pyloric chamber are like those of *Gelasimus*.

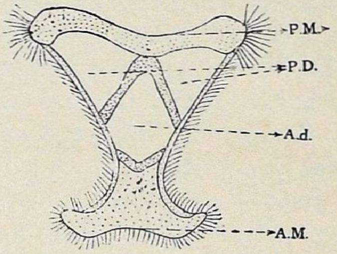
The position of the exopyloric ossicles is different due to the different disposition of the propyloric ossicle.

The propyloric ossicle shows deviation both in structure and disposition. The broader posterior border is rotated to the anterior side, so that its position at rest resembles the position of the propyloric ossicle of *Gelasimus* during action. The exopyloric ossicles are attached to the posterior border and therefore displaced from the position described in *Gelasimus*. This variation in position is responsible for the difference in the mode of action of the entire gastric armature. The ossicle is provided with setae and shows two depressions posteriorly,

and one anteriorly. The posterior end is bifurcated and thickened. The anterior narrow border is attached to the hind end of the uro-cardiac ossicle.



Text Fig. 8.



Text Fig. 9.

TEXT FIG. 8. The Zygo-cardiac ossicle of *Paratelphusa (oziotelphusa) hydrodromus*, Herbst. K′. Inner knob-like termination of the anterior end of the ossicle; K″. Outer knob-like termination. The rest is as in Text Fig. 2.

TEXT FIG. 9. The pro-pyloric ossicle of *Paratelphusa (oziotelphusa) hydrodromus*, Herbst. A.d. Anterior depression; A.M. Anterior margin; P.d. Posterior depression; P.M. Posterior Margin.

The pyloric ossicle is similar to that of *Gelasimus* but there is no transverse chitinisation which gives rise to the transverse bar-like structure in *Gelasimus*. The ossicle shows depression along its median line and the anterior end is not as pointed as that of *Gelasimus*, but is more chitinised.

The pyloric supporting ossicles resemble those of *Gelasimus*.

The mechanism of straining:—The straining apparatus is constituted by (*i*) five pairs of setose cardiac supporting ossicles, namely,

(*a*) the pre-pectinal ossicles.
(*b*) the pectinal ossicles.
(*c*) post-pectinal ossicles.
(*d*) the lateral cardio-pyloric ossicles.
(*e*) the infra-lateral cardiac ossicles.

and by (*ii*) the ampullary ridges which are profusely beset with setae.

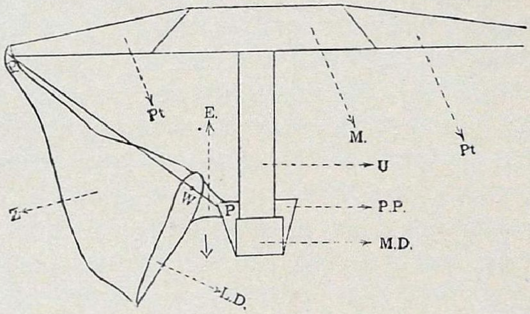
The sub-dentary ossicle does not seem to take part in the composition of the filter.

The anterior ends of the pre-pectinal ossicles articulate with the outer knob-like structures of the anterior ends of the zygocardiac ossicles. They follow the zygocardiac ossicles and gradually become broad at their attachment to the pectinal ossicles. The pectinal ossicles are cup shaped structures bearing towards their inside the infra-lateral cardiac teeth, which are in a level with the lateral teeth on either side of the median tooth. Laterally the pectinal ossicles are attached to the lateral cardio-pyloric ossicles and posteriorly to the infra-lateral cardiac and the post-pectinal ossicles which lie parallel to each other. There are eight to nine sharp denticles on each lateral cardiac tooth. At the position of the lateral cardio-pyloric ossicles the setae are arranged to form brush-like structures rubbing the lateral teeth. Both the infra-lateral cardiac ossicles and the post-pectinal ossicles are thickly beset with setae throughout their entire course. The disposition of the setae is opposed to the direction of the food current. The infra-lateral cardiac ossicles, on reaching the hind end of the pyloric chamber, end in oval setose brushes at the entrance of the fore-gut into the mid-gut. The post-pectinal ossicles on reaching the same place turn up slightly and then bend down ending in anteriorly directed, long, elliptic brushes. These brushes reach as far as the cardio-oesophageal passage. The arrangement of the setae on the ampullary ridges and the membranes extending between the various ossicles is as in the case of *Gelasimus*.

The musculature of the gastric armature resembles that of *Gelasimus*.

The working of the gastric armature seems to be brought about, as Huxley (3) suggested, both by the posterior and the anterior gastric muscles. The peculiar disposition of the propyloric ossicle in the different forms accounts for these differences in the mode of operation. The collision of the ossicles is mainly brought about by the posterior gastric muscle, while the anterior gastric muscle and the cardio-pyloric constrictor muscles are concerned in bringing back the armature to its original condition. If the anterior gastric muscles were mainly responsible for the collision of the ossicles as suggested by Macquard (7) one of the most essential factors, namely the pressing down of the median tooth to meet the colliding zygocardiac teeth could not be accomplished owing to the reverted disposition of the propyloric ossicle. To force the median tooth downwards, the posterior border of the propyloric ossicle, which is bent over to the anterior side, has

to be pulled backwards. This is possible only by the contraction of the posterior gastric muscle. The dorsal border of each zygocardiac ossicle is attached posteriorly to the anteriorly directed posterior border of the propyloric ossicle, on either side, by means of the exopyloric ossicles. Since the posterior gastric muscles are attached to the exopyloric ossicles, the muscles, when they contract, draw the zygocardiac ossicles



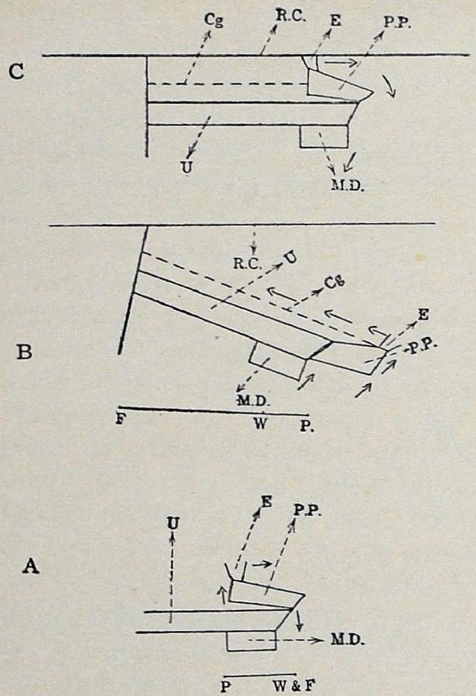
Text Fig. 10.

TEXT FIG. 10. To show the action of the Zygo-cardiac ossicle of *Paratelphusa (oziotelphusa) hydrodromus*, Herbst. The lettering is as in Text Fig. 4.

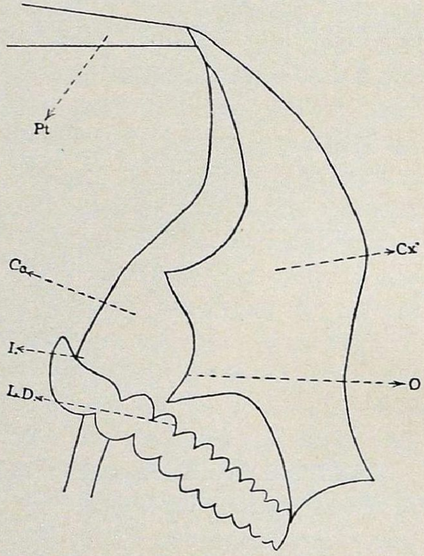
and the propyloric ossicle backwards. The net result is that the urocardiac ossicle with its median tooth is pulled backwards and forced down by the propyloric ossicle to meet the zygocardiac teeth which are also made to collide by the same contraction.

Now if we consider the exopyloric ossicle and the zygocardiac ossicle of each side as one single bar, we have a lever of the second order. But unlike that of *Gelasimus* the fulcrum is at the anterior end, at the place of its atriculation with the outer end of the pterocardiac ossicle. The weight is in the region of the lateral tooth and the power is acting at the exo-pyloric ossicle.

In the case of the propyloric ossicle also we have a lever of the second order. The power acts at the posterior border of the ossicle, while the fulcrum and the weight are at the opposite side of the ossicle, which is attached to the hind end of the urocardiac ossicle. The action of the urocardiac ossicle and the pectinal system of ossicles is similar to that of *Gelasimus*. As in the case of *Gelasimus*, the action of the supporting ossicles alternates with that of the main ossicles. The separation of hard structures in the food-material is effected in the same manner as in *Gelasimus*.



Text Fig. 11.



Text Fig. 12.

TEXT FIG. 11. Diagrammatic representation of the mode of action of the Uro-cardiac and pro-pyloric ossicles of *Paratelphusa (oziotelphusa) hydrodromus*, Herbst. E. Exo-pyloric ossicle. The rest as in Text Fig. 5.

TEXT FIG. 12. The Zygo-cardiac ossicle of *Neptunus pelagicus* (Linnaeus). The lettering is as in Text Fig. 2.

THE GASTRIC ARMATURE OF *NEPTUNUS PELAGICUS (LINN)*.

The mechanism of mastication:—The cardiac chamber is similar to those of *Gelasimus* and *Paratelphusa* but its ossicles vary in structure.

The mesocardiac ossicle is similar to that of *Paratelphusa*.

The urocardiac ossicle is roughly rectangular in shape and is very much thickened. Towards the posterior border it slightly tapers and is attached to the median tooth.

The median tooth differs from that of *Gelasimus* as well as *Paratelphusa* and approaches that of *Cancer pagurus*. It is blunt and dumb-bell shaped, the constricted portion of which lies along the median line of the urocardiac ossicle.

The pterocardiac ossicles show no deviation from the types described before.

The zygocardiac ossicles are narrow anteriorly but become very broad towards the posterior border. Towards the middle of their course they are much calcified and from this region the calcification proceeds towards the lateral teeth in the form of three parallel ridges.

Anteriorly there is one very big denticle in the lateral tooth. This is followed by a second denticle which is comparatively smaller than the first. These two are followed by a number of small sharp denticles. The cardiac supporting ossicles resemble those of *Paratelphusa*. The pyloric chamber shows no deviation. The exopyloric and propyloric ossicles resemble those of *Paratelphusa* both in structure and disposition. The pyloric ossicle exhibits its paired origin remarkably. It is very much elevated both along its midventral and mid-dorsal lines. The anterior conical end does not show any marked chitinisation as in the case of *Gelasimus* and *Paratelphusa*. The pyloric supporting ossicles are like those of previous forms.

The mechanism of straining is composed of the same elements as those of *Paratelphusa*. But here, as in the case of *Gelasimus*, the subdentary ossicle is setose. The prepectinal ossicle does not become broad posteriorly as in the previous forms. The pectinal ossicle differs from the previous ones in being very small and bears the infra-lateral cardiac teeth which are composed of four long pointed denticles. These denticles are very poorly calcified and the anterior-most denticle is the longest, while the others gradually decrease in size towards the posterior end.

The musculature and the mode of operation of the gastric armature are similar to those of *Paratelphusa*.

THE GASTRIC ARMATURE OF *NEPTUNUS SANGUINOLENTUS* HERBST.

The cardiac and pyloric chambers and their ossicles are similar to those of *Neptunus pelagicus*. But some portions of the membranes extend dorsally between the ossicles of the cardiac chamber and are calcified, thereby increasing the efficiency of mastication.

Straining is effected on the same lines as in *Neptunus pelagicus* except that there are six denticles in the infra-lateral cardiac teeth. As in the above, the denticles decrease in size from the anterior to the posterior end. The musculature and the working of the armature are like those of *Paratelphusa*.

THE GASTRIC ARMATURE OF *MATUTA VICTOR* FABR.

The cardiac and the pyloric chambers resemble those of Neptunus. The membranes extending between the ossicles are not calcified. The straining apparatus is constructed on the same lines as those of *Neptunus* and *N. sanguinolentus.* But the subdentary ossicle, as in the case of *Paratelphusa,* is not beset with setae. The musculature and the working of the gastric armature resemble those of *Paratelphusa.*

THE GASTRIC ARMATURE OF *ALBUNEA SYMNISTA* (LINN.)

The cardiac chamber resembles those of the previous forms. The meso-cardiac ossicle is broader in front than behind and is depressed anteriorly. Laterally it is produced into the pterocardiac ossicles, and posteriorly into the urocardiac ossicle. The separation is very indistinct.

The urocardiac ossicle is not very much calcified. It is broader in the middle. The anterior end at its attachment to the mesocardiac ossicle is tapering, while the posterior end first tapers and immediately broadens out at its attachment to the median tooth.

The median tooth is fairly chitinised and consists of a single blunt denticle which is crescent shaped. The convexity of the denticle is directed towards the anterior end.

The pterocardiac ossicles resemble those of *Paratelphusa.*

The zygocardiac ossicles are not as well developed as those of *Paratelphusa.*

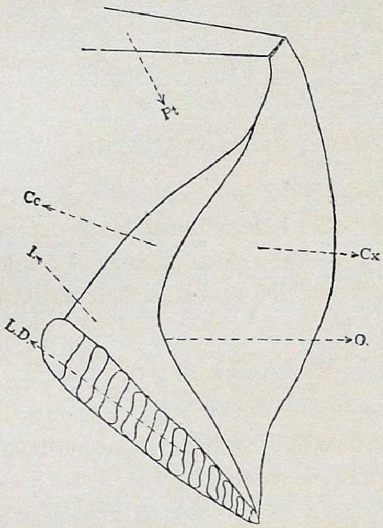
The structure of the denticles on the lateral teeth is uniform unlike those of *Paratelphusa.* But their size decreases as they proceed from the anterior to the posterior end.

The cardiac supporting ossicles are considerably modified and very much differ from those of the previous forms, both in structure and function.

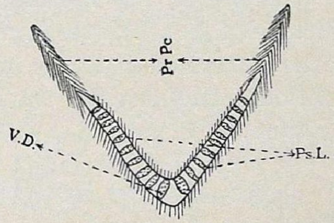
The pyloric chamber and its ossicles are similar to those of the previous forms. The anterior end of the propyloric ossicle is profusely beset with setae which brush against the median tooth. The pyloric ossicle is not well developed as in the previous forms, but is in the form of a cuticular plate. The pyloric supporting ossicles exhibit no deviation.

The straining is mainly effected by setose ampullary ridges of the pyloric chamber. The pre-pectinal, pectinal and post-pectinal and infra-lateral cardiac ossicles, which in the previous forms constitute

the main frame work, are here modified to give rise to a V-shaped masticatory structure. All these ossicles are fused into a single piece, and, posteriorly, the hind ends of the two fused post-pectinal and infra-



Text Fig. 13.



Text Fig. 14.

TEXT FIG. 13. The Zygo-cardiac ossicle of *Albunea symnista,* (Linnaeus). The lettering is as in Text Fig. 2.

TEXT FIG. 14. The 'V'-shaped masticatory structure of *Albunea symnista,* (Linnaeus). Pr.Pc. Pre-pectinal ossicle; Ps.L. The fused post-pectinal and infra-lateral cardiac teeth forming the masticatory structure; V.D. The row of denticles.

lateral cardiac ossicles are fused together, thus giving rise to a V-shaped structure. The free ends of this are the anterior terminations of the pre-pectinal ossicles which are articulated with the outer ends of the pterocardiac ossicles. This structure bears a row of teeth dorsally. These gradually diminish in size as they proceed from the junction of the two fused ossicles on either side to the free ends of the structure. Ventrally there are setae. The denticles extend only as far as the hind end of the prepectinal ossicle. This structure is concerned in mastication rather than in straining. The musculature of the armature resembles those of the previous forms except in that the posterior gastric muscles are inserted mainly in the posterior dorsal borders of the zygocardiac ossicles and the exopyloric ossicles. The working of the armature is different, being correlated with the development of the V-shaped masticatory structure. The fused pectinal system of ossicles which has given rise to this structure

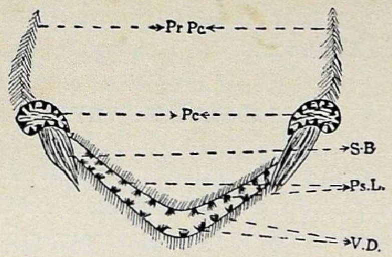
operates simultaneously with the other teeth-bearing ossicles and thus differs from the pectinal system of the ossicles of the previous forms whose working alternates with the working of the main ossicles. It is worked by the posterior infra-lateral cardiac muscles and the lateral cardiac muscles. The denticles of the V-shaped masticatory structure are ventral to the median tooth. In this case also we have a lever of the second order. The fulcrum is at the place of attachment of the pre-pectinal ossicles with the outer ends of the pterocardiac ossicles. The weight is in the region of the row of denticles carried by this structure and the power is applied posteriorly.

Since the median tooth is simple without any furrows on it, there is no possibility of any fresh food-material sticking on it. So there is no need for any mechanism to clean it and hence the structures, which in the previous forms, are mainly concerned in the cleaning of the furrowed median tooth, are here modified for a masticatory function. The rest of the working of the gastric armature shows no deviation.

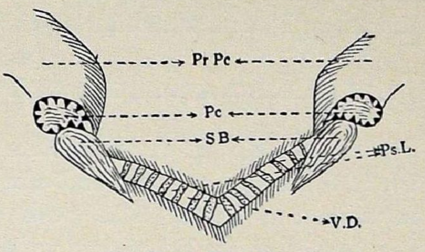
THE GASTRIC ARMATURE OF *CLIBANARIUS LONGITARSUS*, de HAAN.

The cardiac and the pyloric chambers and their ossicles resemble those of *Albunea* in most respects except in the shape and the structure of the mesocardiac and the urocardiac ossicles and the median tooth.

The mesocardiac ossicle is very well developed and comparatively big. It is comparatively broadened at the median line and suddenly tapers to give rise on either side to the pterocardiac ossicles. It is indistinctly separated from the pterocardiac ossicles but marked off from the urocardiac ossicles. The urocardiac ossicle narrows posteriorly and to this the median tooth is attached. The median tooth is bi-convex and surrounded by setae projecting from the anterior end of the propyloric ossicle. The straining is effected as in the case of *Albunea*. Here also the pectinal system of ossicles is modified to give rise to the V-shaped masticatory structure; but the modification is slightly different. The pectinal ossicles on either side are quite distinct and they carry the infra-lateral cardiac teeth, just below which there is a setose brush. Posteriorly the infra-lateral cardiac ossicle and the post-pectinal ossicle are fused together. The two arms of the V-shaped structure are more divergent than in *Albunea*. Dorsally the structure bears sharp denticles, while the ventral surface is setose. The musculature and the mode of operation of the armature is similar to that of *Albunea*.



Text Fig. 15.



Text Fig. 16.

TEXT FIG. 15. The 'V'-shaped masticatory structure of *Diogenes custos,* Herbst. Pc. Pectinal ossicle ; S.B. Setose bush-like structure. The rest is as in Text Fig. 14.

TEXT FIG. 16. The 'V'-shaped masticatory structure of *Clibanarius longitorsis,* Henderson. The lettering is as in Text Figs. 14 and 15.

THE GASTRIC ARMATURES OF *CLIBANARIUS AQUABITES de DANA C. OLIVACEOUS HENDERSON, C. ARETHUSA de MAN,* AND *C. INFRASPINCTUS HILGENDAT.*

All these resemble the previous form. But in the case of *C. infraspinctus,* the membranes extending between the ossicles of the cardiac chamber are calcified.

THE GASTRIC ARMATURE OF *DIOGENES CUSTOS,* FABR.

The cardiac and the pyloric chambers and their ossicles resemble those of *Albunea* and *Clibanarius,* except in the structure of the mesocardiac and the urocardiac ossicles and the median tooth. The mesocardiac ossicle is broad in the middle and is indistinctly separated from the pterocardiac ossicle and the urocardiac ossicle. The urocardiac ossicle is in the form of a broad rectangular plate, the posterior end of which bears the median tooth. The median tooth is produced into three posteriorly directed spine-like processes, the central of which being the most calcified and chitinised. The setae from the anterior border of the proplyoric ossicle surround the tri-radiate median tooth.

The straining is similar to that of *Clibanarius longitarsus*. The V-shaped masticatory structure carrying the denticles is comparatively broader. The infra-lateral cardiac teeth are more chitinised here than those of *Clibanarius,* and the whole structure is more profusely beset with setae. The musculature and the working of the armature are

similar to those of the *Clibanarius*. The gastric armature of *Diogenes diogenes*, Herbst is similar to that of *D. custos*.

THE GASTRIC ARMATURE OF *PENAEUS INDICUS*, M. EDWARDS.

It shows certain resemblances to that of *Cerataspis monstrosus*, which is the simplest type, and also a few features characteristic of the more advanced types. The cardiac chamber is very much elongated and is considerably broadened in the middle. The mesocardiac ossicle is a triangular piece of sclerite, placed in the roof of the broadest portion of the cardiac chamber. The base of the triangle is situated anteriorly ; the central region and the sides are thickened and calcified.

The urocardiac ossicle is attached anteriorly to the posteriorly directed apex of the triangular, mesocardiac ossicle. It is a rod-like structure narrowed in the middle, and in its posterior end, shows two crescentic chitinisations with an intervening concavity. The posterior end is attached to the median tooth.

The median tooth is also a triangular structure, whose anteriorly directed base is attached to the hind end of the urocardiac ossicle. The apex bears a single big denticle which is followed by nine to eleven smaller denticles. The large apical denticle projects into the cardio-pyloric passage.

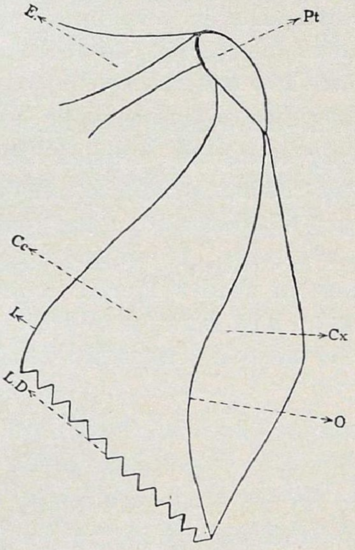
The structure of the cardiac ossicle and the urocardiac ossicle and the median tooth resembles that of *Nephrops*. In the case of *Nephrops* the triangular, median tooth is not differentiated into denticles.

The pterocardiac ossicles are very much reduced and are attached to the base of the mesocardiac ossicle on either side. They are similar to those of *Nephrops* and *Astacus*.

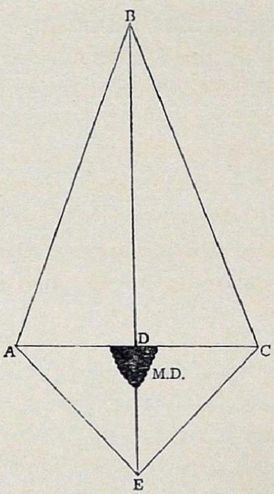
The zygocardiac ossicles are attached to the posterior ends of the pterocardiac ossicles. They are narrow anteriorly, becoming gradually broadened towards the hind end. They do not exhibit any complicated folding. The posterior border bears the lateral teeth on either side of the median tooth. Each lateral tooth is composed of a uniform row of sharp denticles.

The noteworthy feature about the gastric armature of *Penaeus* is a long row of sharp, accessory denticles along the lateral folds of the cardiac chamber, extending from the middle of the zygocardiac ossicle on either side, as far as the anterior extremity of the elongated cardiac chamber. All the denticles are of uniform structure. These longi-

tudinal rows of denticles together with the denticles of the lateral teeth show a striking resemblance to the two longitudinal lateral rows of denticles along the lateral folds of the cardiac chamber of *Ceratas-pis monstrosus.* These rows of denticles in *Penaeus*, from their relative position, can be termed the " supra-lateral " cardiac teeth.



Text Fig. 17.



Text Fig. 18.

TEXT FIG. 17. The Zygo-cardiac ossicle of *Penaeus indicus,* Milne. Edwards. M. Meso-cardiac ossicle. The rest is as in Text Fig. 2.

TEXT FIG. 18. The schematic representation of the relative arrangement of the supra-lateral cardiac teeth, infra-lateral cardiac teeth and the median tooth. A.B. & B.C. The two rows of supra-lateral cardiac teeth ; A.E. & C.E. The two rows of infra-lateral cardiac teeth ; D. The point of intersection of the diagonals of the rhombus-like figure formed by the above mentioned two sets of teeth ; M.D. Median tooth.

The cardiac supporting ossicles are not differentiated, but their position is indicated by the V-shaped row of sharp and uniform denticles present below and bounding the median tooth. These correspond to the infra-lateral cardiac teeth, carried by the pectinal ossicles of the previous forms. It is interesting to note that the supra-lateral cardiac teeth and the infra-lateral cardiac teeth form a rhombus-like outline. The median tooth is situated almost at the point of intersection of the diagonals. The apex of the triangular median tooth lies along AB while the base lies along CD as indicated in the Text Fig. 18.

The pyloric chamber is differentiated into an anterior spacious division and a posterior division where the ampullary system of ridges is developed. The pyloric ossicles are not well differentiated.

The masticatory mechanism in *Penaeus* seems to be intended for tearing soft food material into smaller pieces rather than for crushing hard food-materials. The examination of the gastric contents of a number of these animals confirms this view. The hard shell-like structures of animals taken in as food, met with in the gastric chambers of almost all the previous forms, were not noticed in this case.

Another very peculiar feature of the masticatory mechanism is the occurrence of certain masticatory structures outside the gastric region. There is a group of six sharp chitinous denticles in the posterior end of the œsophagus. They project down from the dorsal wall and their pointed ends are directed ventrally. These are probably intended for the preliminary reduction of food materials before they are actually sent down for the regular masticatory and straining processes. Such structures are not met with in any other form so far studied.

The straining is effected by the profuse setae present in the ampullary, inter-ampullary and supra-ampullary ridges. The musculature resembles that of *Astacus fluviatus*.

The working of the armature is slightly different from the previous forms. The median tooth does not seem to have a downward movement, but has only a backward and forward movement which is effected by the anterior and the posterior gastric muscles. The lateral teeth seem to work against the median tooth. The working of the zygocardiac ossicles is similar to those of *Paratelphusa*.

The supra-lateral cardiac teeth and the infra-lateral teeth are worked by the lateral cardiac muscles. The œsophageal armature appears to be worked by the posterior œsophageal dilator and depressor muscles.

SUMMARY AND CONCLUSION.

1. The general plan of the gastric armatures is fundamentally the same in the different forms studied.

2. The structural details vary particularly in the case of the following :—

(*a*) The urocardiac ossicle and the median tooth.
(*b*) The denticles carried by the masticatory sclerites.
(*c*) The setae constituting the straining devices.

3. The *modus operandi* of the armature also differs in correlation with the disposition of the propyloric ossicle.

4. The musculature of the armature is slightly varied, depending on the disposition of the propyloric ossicle.

5. In some forms like *Diogenes, Clibanarius* and *Albunea* additional masticatory structures are developed by the modification of the pectinal system of ossicles.

6. The working of the pectinal system of ossicles differs, depending on the fact whether they are for mastication or for straining ; if they are for straining, their action alternates with that of the main teeth-bearing ossicles, and if masticatory, it is simultaneous.

7. The gastric armature of *Penaeus indicus* differs from that of the rest in the development of the following structures :—

(*a*) The œsophageal armature outside the gastric region.

(*b*) Supra-lateral cardiac teeth along the lateral folds of the cardiac region.

8. The gastric armatures of the forms so far studied present a well graded series of complexities. *Cerataspis monstrosus* described by Bonier, presents a most primitive type. The gastric armature of *Penaeus indicus* is intermediate between this primitive and more advanced types. *Nephrops norwegicus* and *Astacus fluviatus* come next in the series, followed by *Albunea symnista,* and the different species of *Diogenes* and *Clibanarius, Paratelphusa,* (*Oziotelphusa*) *hydrodromus, Cancer pagurus, Neptunus pelagicus* and *N. sanguinolentus, Matuta victor* and *Gelasimus annulipes,* in the order of increasing complexity of the gastric armature.

In conclusion I have great pleasure in expressing my best thanks to Mr. H. Channapayya, Zoologist Govt. Museum, Madras for the identification of the species and to Dr. S. G. Manavala Ramanujam, Professor of zoology, Presidency College, Madras, and Mr. R. V. Seshaiya, Lecturer in zoology, Annamalai University, for valuable suggestions and guidance.

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THE EXPLANATION OF PLATES *

Ar ; Ampullary ridges beset with stetae.

Co. ch. Cardiac chamber.

C. M. R. Cardiac median ridge.

E. P. Exopyloric ossicle.

Inf. C. Infra-lateral cardiac ossicle.

Inf. L.T. Infra-lateral teeth.

K′. Inner knob-like terminations of the anterior end of the zygocardiac ossicle.

K″. Outer knob-like termination of the anterior end of the zygocardiac ossicle.

L. C. P. Lateral cardio-pyloric ossicle.

L. T. Lateral teeth.

M. Mesocardiac ossicle.

M. D. Median tooth.

Oe.D. Œsophageal group of denticles.

P. Pyloric ossicle.

Pc. Pectinal ossicle.

P.ch. Pyloric chamber.

Pt. Pterocardiac ossicle.

P. P. Propyloric ossicle.

Pr. Pc. Pre-pectinal ossicle.

Ps. L. The V-shaped masticatory structure.

Ps. Pc. Post-pectinal ossicle.

S. Setae.

S. B. Setose brush.

S. D. Sub-dentary ossicle.

Sup. L. T. Supra-lateral cardiac teeth.

T.P.B. Transverse pyloric chtinous bar-like structure.

U. Urocardiac ossicle.

Z. Zygocardiac ossicle.

* The plates as well as the text figures are semi-diagrammatic.

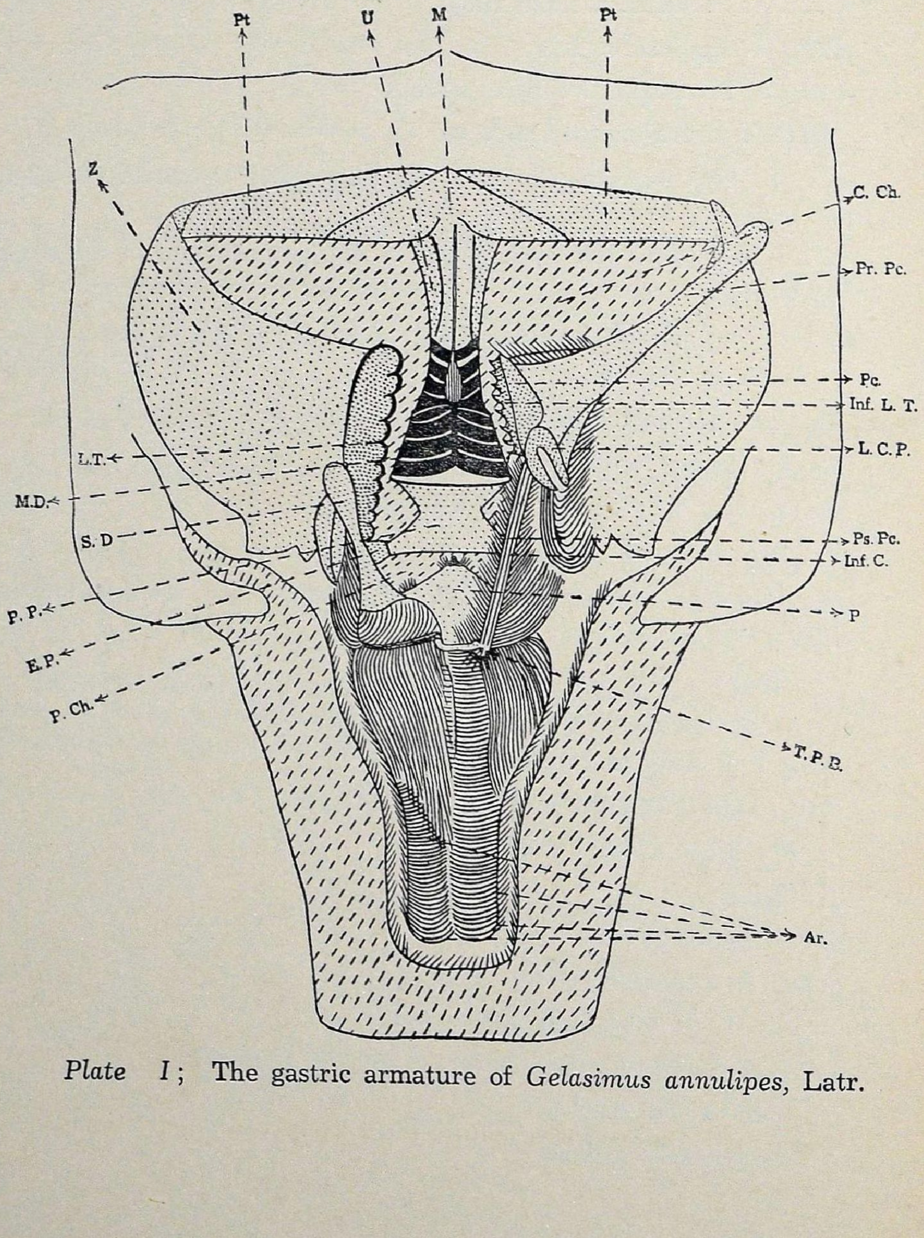


Plate I; The gastric armature of *Gelasimus annulipes*, Latr.

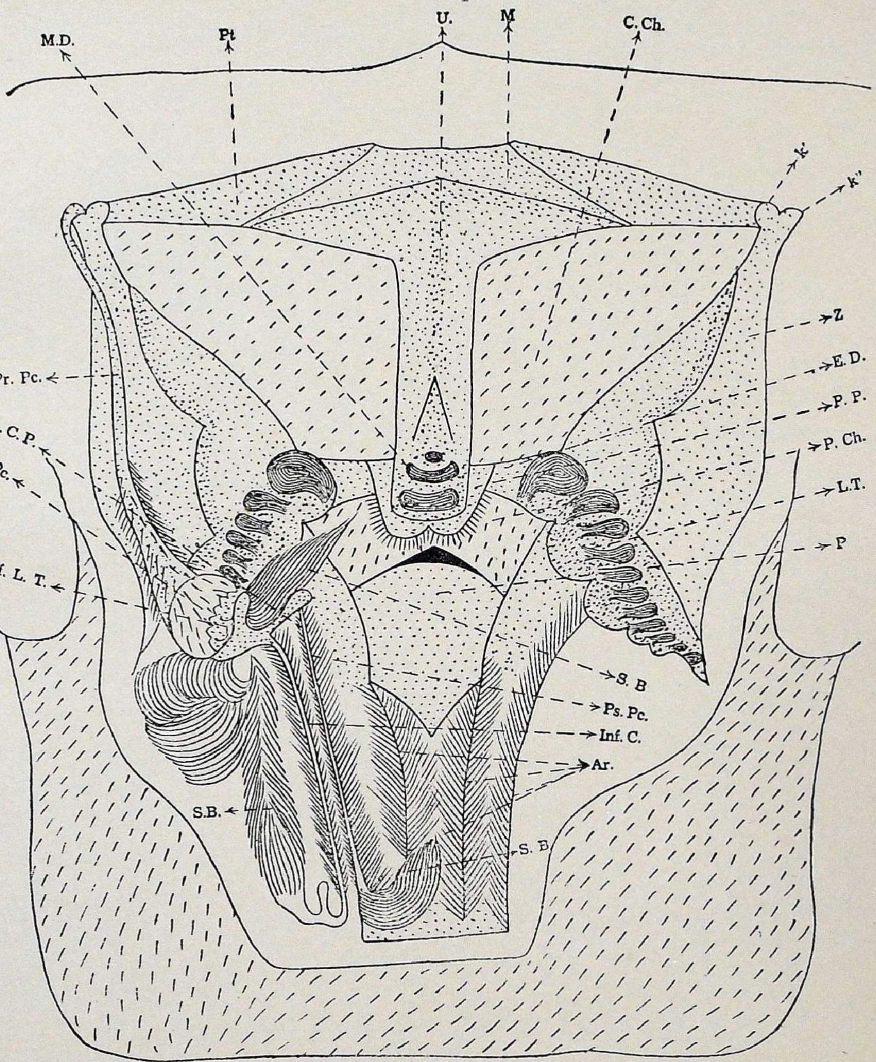


Plate II ; The gastric armature of *Paratelphusa hydrodromus*, Herb.

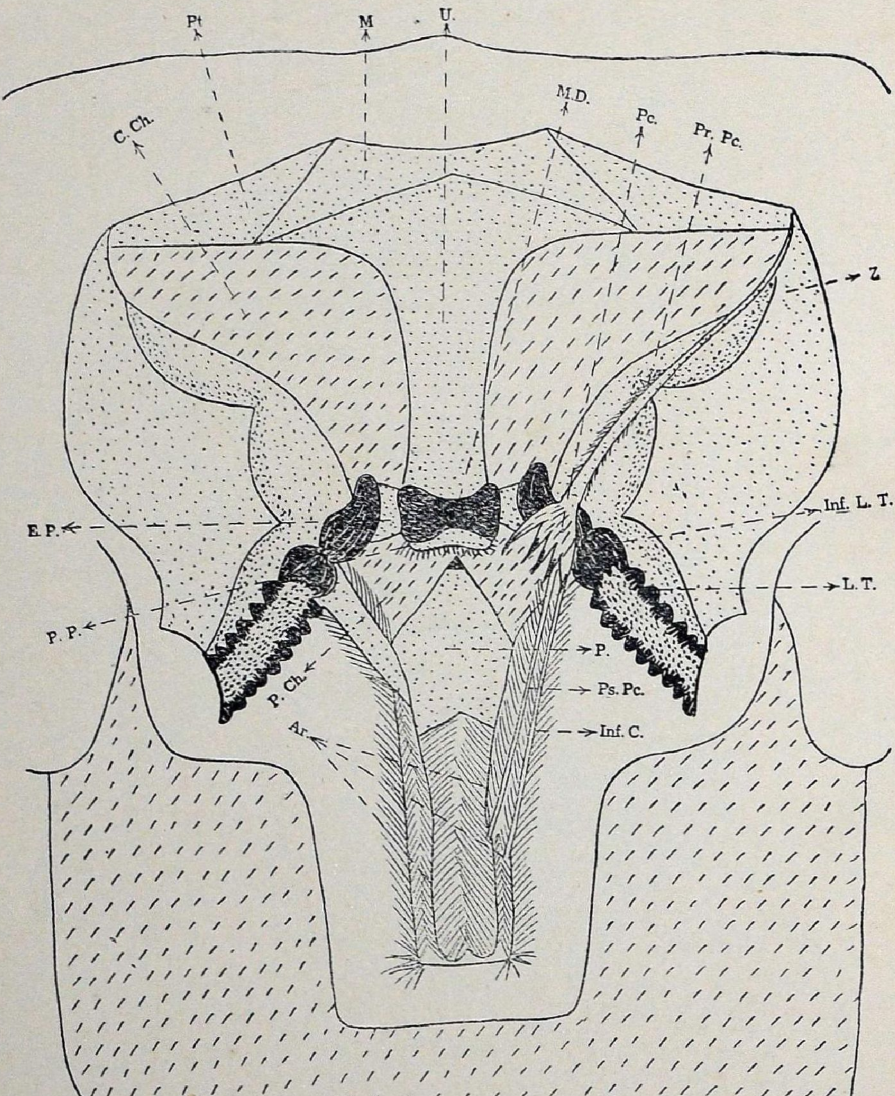


Plate III ; The gastric armature of *Neptunus pelagicus*, (Linn).

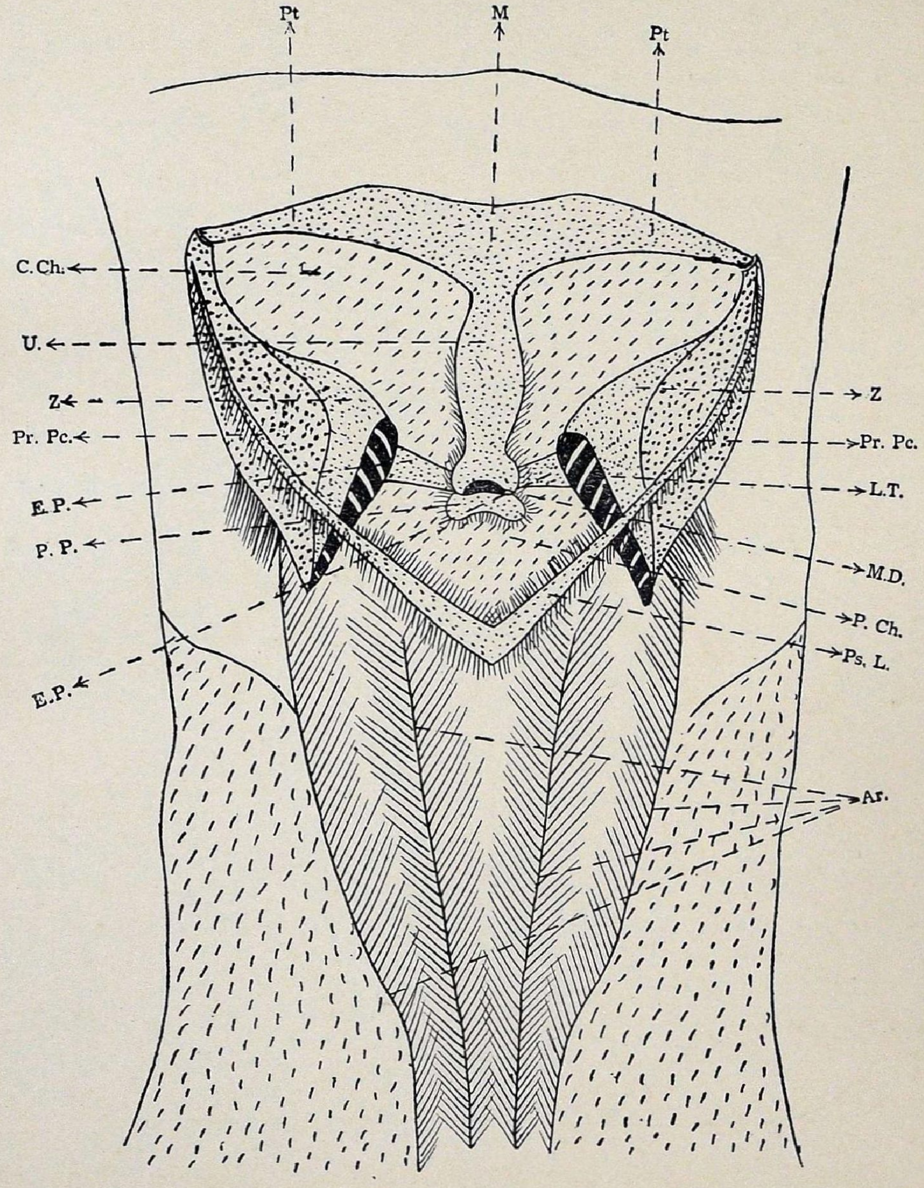


Plate IV ; The gastric armature of *Albunea symnista*, (Linn).

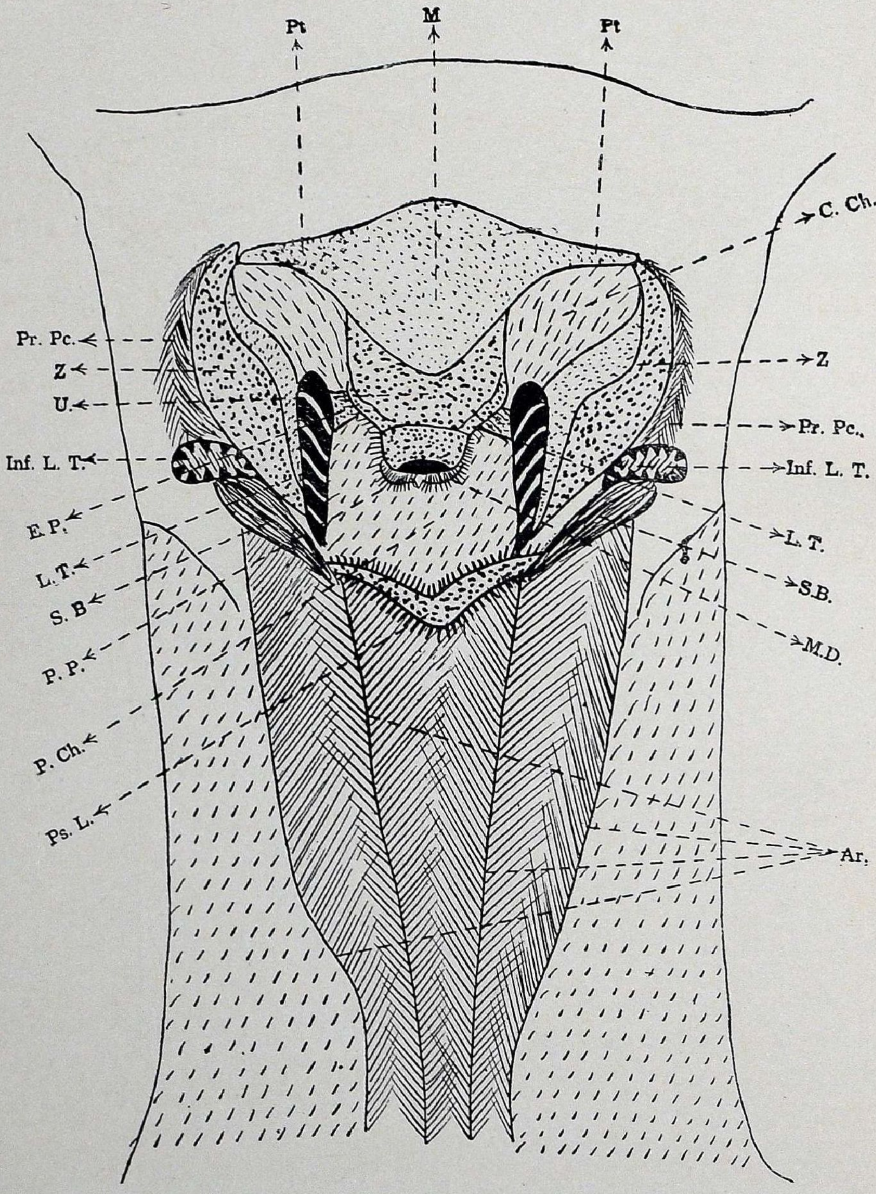


Plate V; The gastric armature of *Diogenes custos*, Fabr.

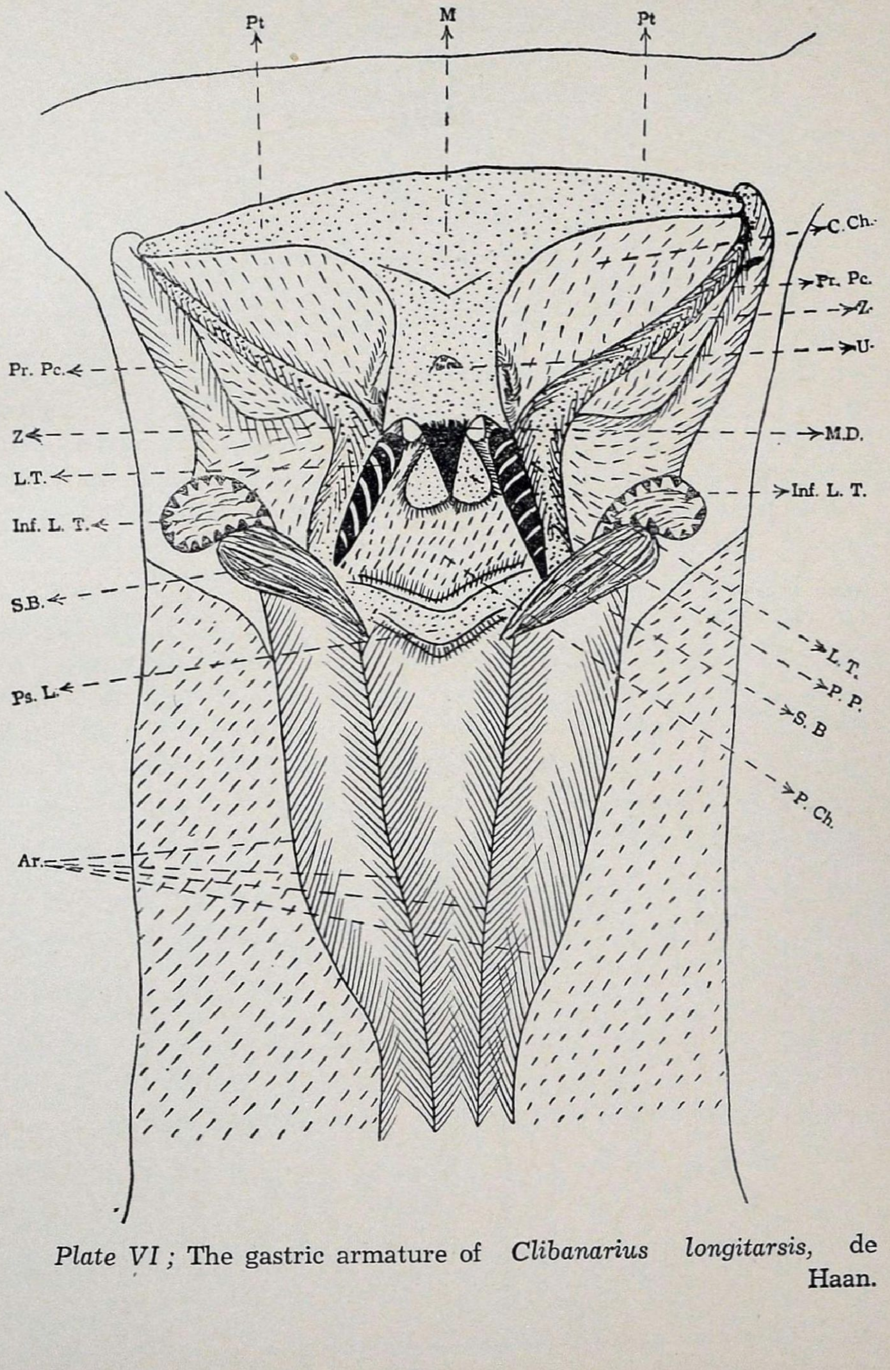


Plate VI; The gastric armature of *Clibanarius longitarsis*, de Haan.

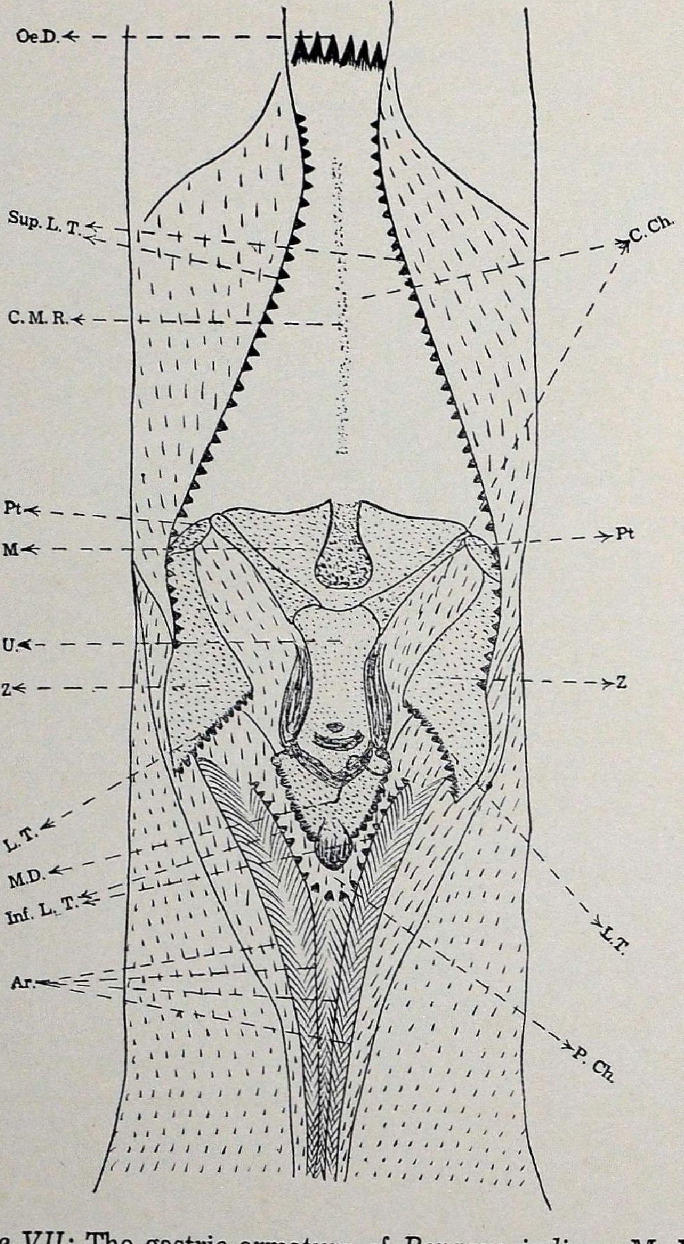


Plate VII; The gastric armature of *Penaeus indicus*, M. Edw.

The Syllogistic Machine

Designed and Constructed

BY

P. S. Naidu

(Annamalai University.)

INTRODUCTION.

The machine is a contrivance for obtaining automatically the conclusions from the valid moods of the Aristotelian Syllogism. The main feature of the device is that it shows up mechanically the valid moods and their conclusions together with their respective 'mnemonic' names, but presents a blank whenever a fallacious combination of premises is made.

Of the sixty four possible combinations of the eight Major premises, MAP, PAM, MEP, PEM, MIP, PIM, MOP and POM with the eight Minor premises, SAM, SEM, SIM, SOM, MAS, MES, MIS, and MOS, only nineteen are valid. These valid moods have been neatly fitted into the 'mnemonic' lines. These moods with their conclusions may be tabulated as indicated below:

	MAP	MEP	MIP	MOP	PAM	PEM	PIM	POM
SAM	A	E				E		
SEM					E			
SIM	I	O				O		
SOM								
MAS	I	O	I	O	I	O	I	
MES					E			
MIS	I	O				O		
MOS								

Fig. I.

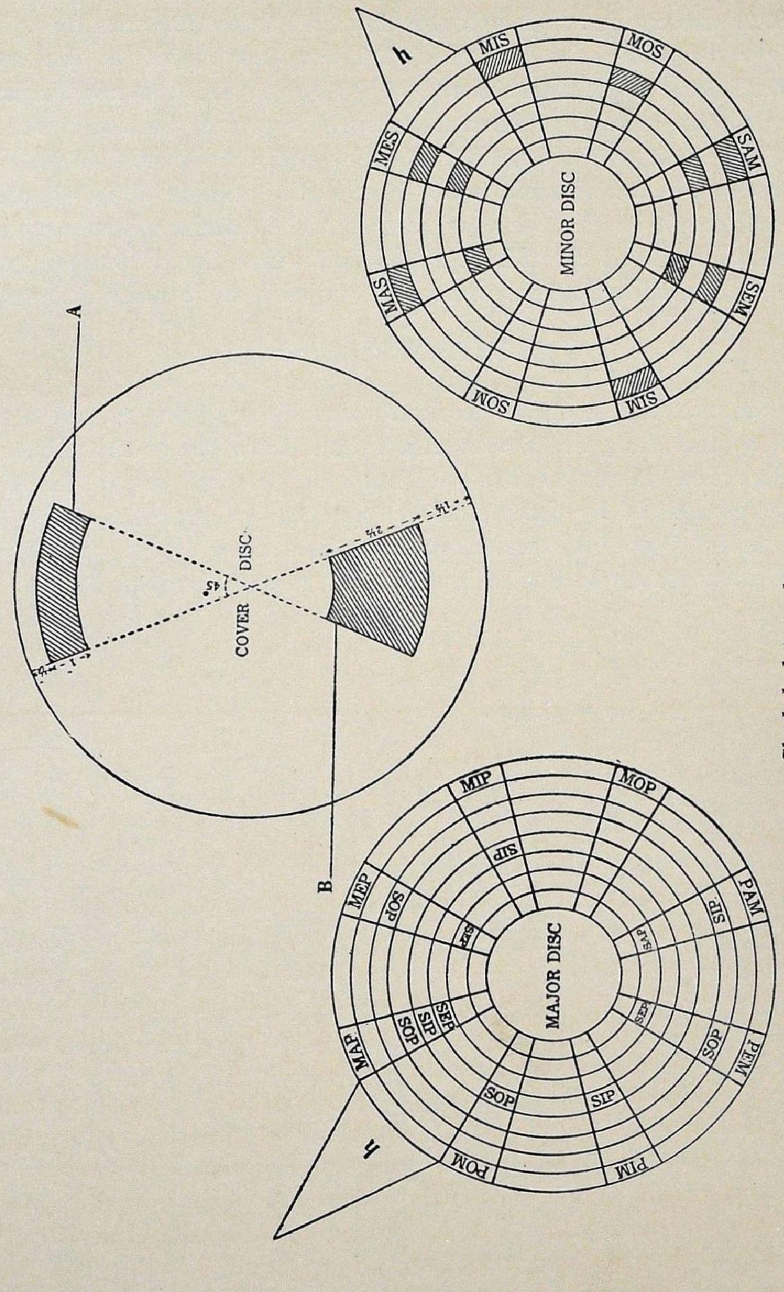
An examination of the table reveals the identical nature of the conclusions obtainable from (1) MEP & PEM, (2) MIP & PIM, (3) SEM & MES, (4) SIM & MIS. Omitting POM & MOS, which are inefficient as premises, the table may be abridged as shown in Fig. II.

	MAP	MEP or PEM	MIP or PIM	MOP	PAM
SAM	A	E			
SEM or MES					E
SIM or MIS	I	O			
SOM					O
MAS	I	O	I	O	I

Fig. II.

THE ORIGINAL DESIGN.

The compactness of the table and the syllogistic symmetry (vide app. I.) observable therein suggested the possibility of constructing a 'thinking machine.' The problem, as it presented itself in the earliest stages, was to design a suitable mechanical arrangement which would, when the valid premises came together, reveal their respective conclusions, but merely show up blank space in the case of invalid combinations. The following is a description of the first design. Three circular discs, known as the 'Major,' the 'Minor,' and the 'Cover Discs,' of radii 4½″, 4″, and 5″ respectively, are cut out of thin white card board. Nine concentric circles are drawn on the 'Major' and eight on the 'Minor,' their radii decreasing uniformly by ½″. Each disc is then divided into twenty-four equal sectors. The Major premises and the conclusions are written on the 'Major' disc as shown in Fig. iii.



Shaded slots to be cut out.
h—handles (Major handle should be longer than the minor).
Fig. III.

The minor premises are written round the edge of the 'Minor' disc, and eleven slots are cut out at the places indicated in the figure. Two 'Windows' are cut out of the 'Cover' disc. The three discs are then placed one over the other, the 'Cover' at the top, the 'Major' at the bottom and the 'Minor' in between them, with a strong knitting needle passing through their common centre and serving as an axis for rotation. The 'Cover' disc is kept fixed, and the 'Major' and 'Minor' are rotated. As often as a valid combination is obtained at the window A its conclusion is seen through B. In the case of all invalid combinations nothing is seen through B. It should be noted here that the sub-altern moods of the weakened syllogisms appear along with their normal forms.

THE IMPROVED DESIGN

When this simple device worked successfully giving complete satisfaction to the designer, it was considered desirable to introduce into the discs the names of the valid moods as well as those of the fallacies committed by the invalid combinations of premises. The sixty four combinations, the conclusions, and the names of the valid moods, and of fallacies in the case of invalid ones, are set forth in Fig. iv.

Fig. IV.

	* MAP	* MEP	* MIP	* MOP	* PAM	* PEM	* PIM	*POM
SAM	I SAP BARBARA	I SEP CELARENT	*UN : MD*	*UN : MD*	*UN : MD*	II SEP CESARE	*UN : MD*	*IL : MJ*
SEM	*IL : MJ*	*2—VE*	*IL : MJ*	*2—VE*	II SEP CAMESTRES	*2—VE*	*IL : MJ*	*2—VE*
SIM	I SIP DARII	I SOP FERIO	*2 : PART*	*2 : PART*	*UN : MD*	II SOP FESTINO	*2 : PART*	*2 : PART*
SOM	*IL : MJ*	*2—VE*	*2 : PART*	*2—VE*	II SOP BAROCO	*2—VE*	*2 : PART*	*2—VE*
MAS	III SIP DARAPTI	III SOP FELAPTON	III SIP DISAMIS	III SOP BOCARDO	IV SIP BRAMANTIP	IV SOP FESAPO	IV SIP DIMARIS	*IL : MJ*
MES	*IL : MJ*	*2—VE*	*IL : MJ*	*2—VE*	IV SEP CAMENES	*2—VE*	*IL : MJ*	*2—VE*
MIS	III SIP DATISI	III SOP FERISON	*2 : PART*	*2 : PART*	*UN : MD*	IV SOP FRESISON	*UN : MD*	*IL : MJ*
MOS	*IL : MJ*	*2—VE*	*2 : PART*	*2—VE*	*UN : MD*	*2—VE*	*2 : PART*	*2—VE*

(The Roman numerals indicate the syllogistic figures. The conclusions and the names of the corresponding moods are given underneath the figures. The fallacies are printed in italics.

UN : MD stands for Undistributed Middle. *2—VE* stands for Double Negative Premises.
IL : MJ „ „ Illicit Major. *2 : PART* „ „ Two Particular Premises.)

The problem of fitting these into the original discs was solved by increasing the number of circles to 17 in each case. The appearance of the machine in its final form is somewhat similar to that of a Radio Receiver. (Fig. V.) The two dials (the 'Major' and the 'Minor') are mounted on horizontal spindles and can be rotated independently of each other by the knobs X and Y. The front panel contains two openings and electric bulbs are mounted on the back panel to illuminate the dials from behind. The arrangement of the premises, the conclusions, etc., is shown in detail in Figs. VI and VII.

CHARACTERISTICS OF THE MACHINE.

The following features of the machine may be mentioned:—

(1) It is simple in operation.

(2) Along with the universal conclusions their corresponding subalterns also appear through the lower opening of the front panel. But it was considered unnecessary to introduce the mutilated mnemonic words for them.

(3) With regard to the fallacies, it was necessary to select one from each group of several possibilities. For example, in the case of the combination MIP—MOS, the group consists of (1) two particulars, (2) undistributed middle and (3) illicit major. Of these (2) has been chosen. In picking out the fallacies reference to the conclusion has been avoided as far as possible. An attempt has also been made to keep to the fundamental rules, but reference to the corollaries is unavoidable in certain cases. When these considerations are borne in mind, the reason for the choice of a particular fallacy in any given case will be evident.

(4) The machine, it is believed, is the first of its kind.

APPENDIX I.

The special rules of the Figures express the qualitative relationships subsisting between their premises and the conclusions. The following numerical relationships may also be deduced from these rules.

The Valid Moods.

FIG	I	AAA	EAE	AII	EIO		
FIG	II	EAE	AEE	EIO	AOO		
FIG	III	AAI	IAI	AII	EAO	OAO	EIO
FIG	IV	AAI	AEE	IAI	EAO	EIO	

I

The number of times that A, E, I, and O appear as conclusions in each figure.

	A	E	I	O	Total No. of conclusions in each Fig.
Fig I	1	1	1	I	4
Fig II	0	2	0	2	4
Fig III	0	0	3	3	6
Fig IV	0	1	2	2	5
Total	1	4	6	8	19
		(2 x 2)	(2 x 3)	(2 x 4)	

II

The number of possible combinations of any given major or minor with the several minor and major premises.

Major	MAP	MEP	MIP	MOP	PAM	PEM	PIM	POM	Total
No :	4	4	I	1	4	4	1	0	19
Minor	SAM	SEM	SIM	SOM	MAS	MES	MIS	MOS	
No :	3	1	3	1	7	1	3	0	19

III

The number of times that A, E, I and O occur as major or minor.

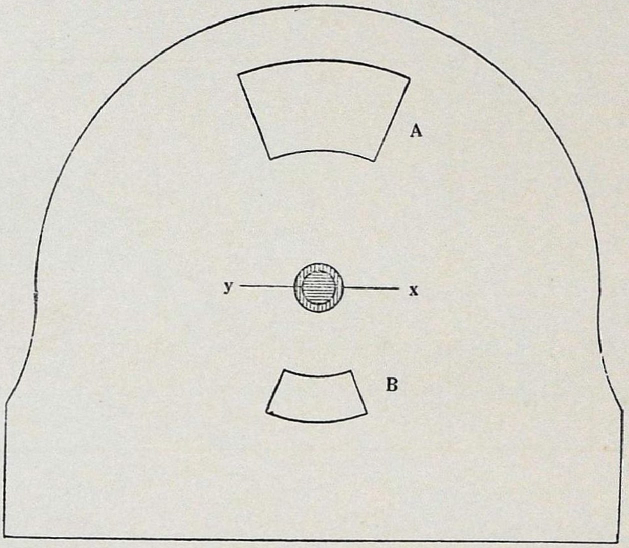
Major

Minor	A	E	I	O	Total
A	3	4	2	1	10
E	2	0	0	0	2
I	2	4	0	0	6
O	1	0	0	0	1
Total	8	8	2	1	19

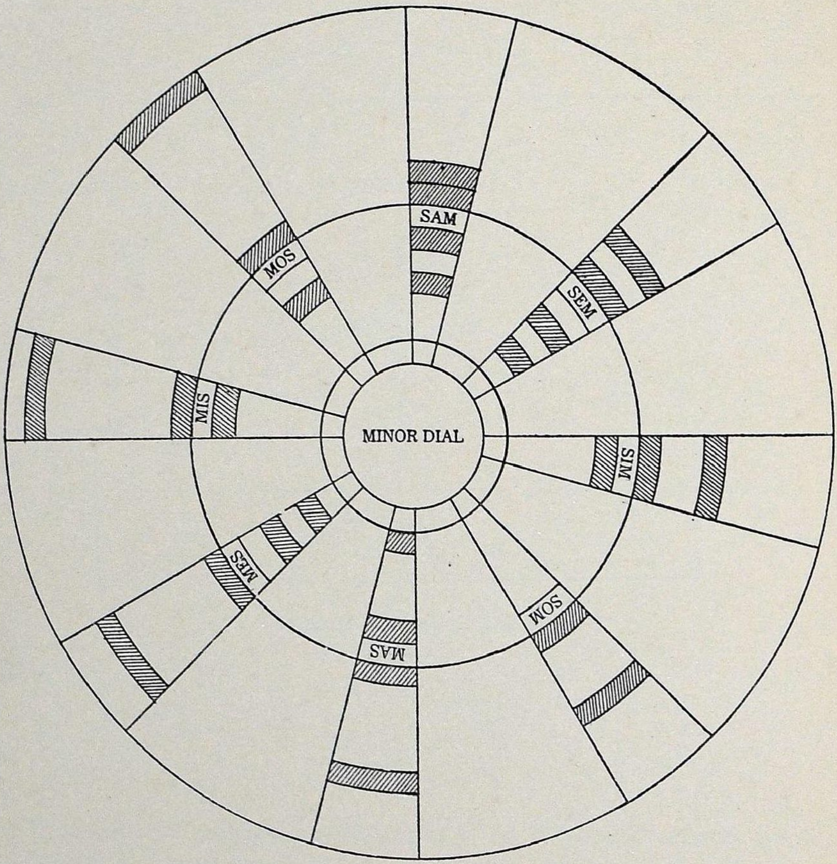
IV

The number of possible combinations of A, E, I and O among themselves taken two at a time.

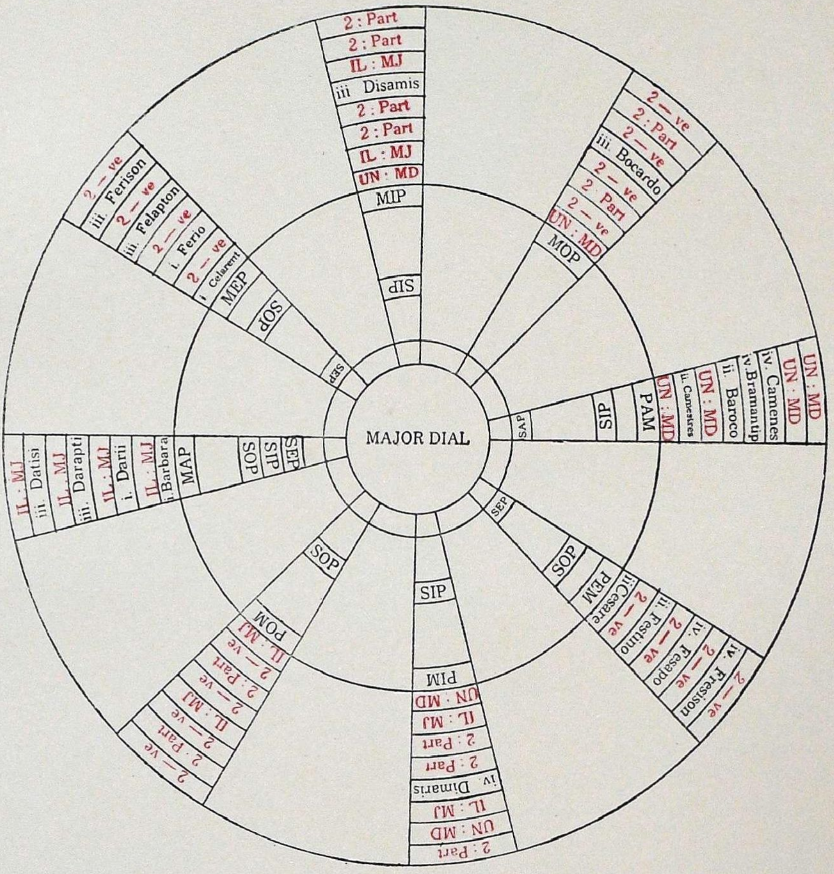
	AA	AE	EA	AI	IA	AO	OA	EI	Total
	3	3	3	2	2	1	1	4	
Total	3	6		4		2		4	19



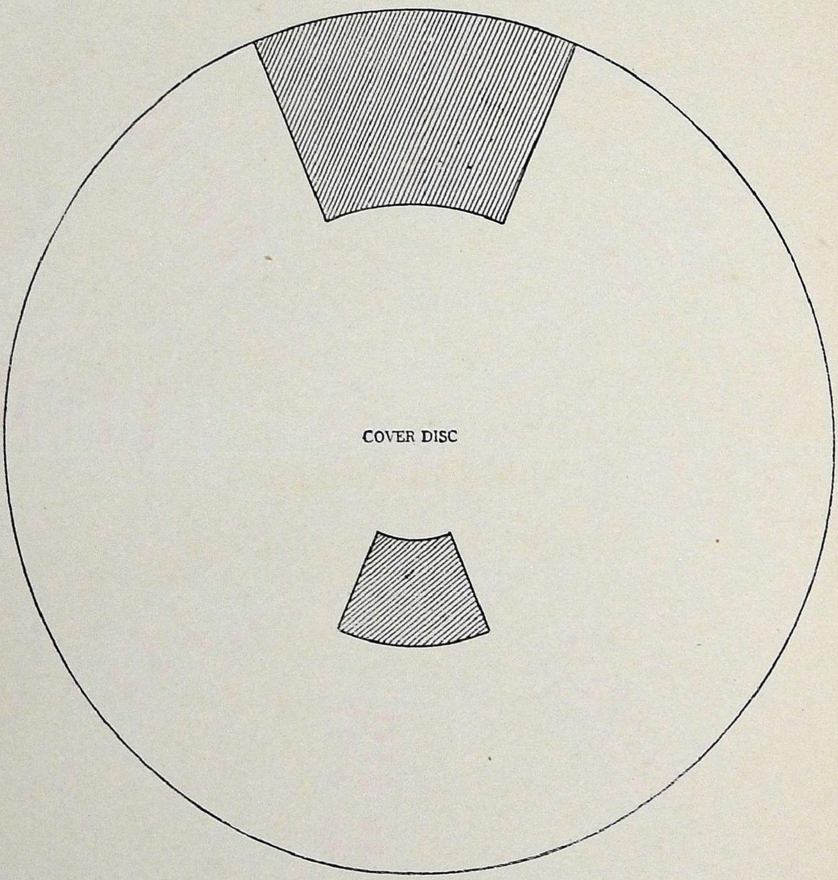
The Syllogistic Machine.
Fig. V.



The Minor Dial.
Shaded slots to be cut out.
Fig. VI.



The Major Dial.
The Fallacies are printed in Red.
Fig. VII.



The Cover Disc.
Shaded slots to be cut out.
Fig. VIII.

(N.B.—The dials in figures VI, VII, and VIII may be copied to suitable scale and rotated round their common centre. Bristol Board and Indian Ink are recommended for this purpose.)

Abhiṣeka-Nāṭaka

(An English Translation with Notes.)

K. R. Pisharoti

Abhiṣeka-Nāṭaka

ACT I.

[*Then at the end of* Nandi *enter* Sūtradhāra[1]]

Sūtradhāra.

[2]Who destroyed the enemies of the Sacrifice of the son of Gādhi, who overcame in battle the valour of Virādha, Khara and Dūṣaṇa and who killed the proud and haughty Kabandha and the Lord of *Vānaras*—may He, the Destroyer of the race of the Lord of *Rākṣasas*, protect you. **(1)**

Thus do I wish to inform you, worthy sires. [*Wandering about and looking*] Ah! what is this sound that I hear when I am about to speak? Ah, I see:

[*In the postscenium.*]

This way, Sugrīva, this way.

Pāripārśvaka. [*Entering*] Friend!

Whence has this loud sound arisen, which pierces the ears and which is similar unto the roaring in the sky of the massive clouds, driven by fierce winds? **(2)**

1. This has all along been one of the dramas very popular among the Cākyars, who are the professional actors attached to the more important temples in Kerala. They call this drama *Ceriya-abhiṣeka* to distinguish it from the *Valiya-abhiṣeka,* i.e., the *Āścaryacūḍāmaṇi* of Śaktibhadra. The fourteen acts of these dramas *plus* the seven acts of the *Pratimā-nāṭaka,* locally known as *Vicchinnābhiṣeka,* constitute the twenty-one acts, familiar on our stage in Kerala, depicting the life and career of Śrī Rāma.

2. Note the nature of the *Sthāpana.* This is not exactly like the *Sthāpana* found in the other dramas of the series *wrongly* styled the *Bhāsa-nāṭaka-cakra.* As a matter of fact, it could very well have been cut down. The longer explanation of what the sound was has been given possibly with a view to distinguish it from the other *Rāma-nāṭakas.*

Sūtradhāra. Friend, don't you know? This announces the preparation to compass the death of the golden wreathed Bāli, the king of all *Vānaras,* made by Rāma and Sugrīva who have signed a compact for mutual help—Rāma, the light of the *Raghu* race and the delight of the world, who bemoans the loss of his wife and Sugrīva, the broad necked lord of *Haris* and *Ṛkṣas,* who has been driven away from his kingdom for making overtures to his wife.[3] And indeed the two,

> Rāma and Lakṣmaṇa, are now come up to reinstate Sugrīva exiled from his kingdom, like Hari and Hara come to reinstate Indra. (3)

[*Exeunt.*

STHĀPANA.

3. The two great heroes, Rāma and Sugrīva, are alike: both are exiles from their home and in the exile a woman is implicated; both are grieving over the loss not so much of their kingdom as of their beloved and both again have only a single devoted follower, Lakṣmaṇa and Hanūmān. No wonder they are brothers in distress and they entered into an alliance the moment they came together.

[*Then enter* Rāma, Lakṣmaṇa, Sugrīva *and* Hanūmān.]

Rāma. Sugrīva, this way, this way.

Now shall I quickly fell down to the ground your enemy killed with my arrows and his body cut up. Cast off, O king, thy fear, (for) thou standst by my side[4]; and see that Bāli killed in battle. (4)

Sugrīva. Lord, through thy grace I may dare covet even the kingdom of Gods; what, then, need be said of the kingdom of *Vānaras*?

I have no doubt that your arrows, when discharged, will at once pierce the heart of Bāli—the arrow which pierced in the forest the seven *śala* trees, similar unto the snow-clad mountain, and which on account of its force entered the earth, reached the abode of the *Nāgas* and after bathing in the ocean, came back to you. (5)

Hanūmān.

By these words which flow out from your mouth, we have, O King, our fears lulled and our sorrows driven away. O, thou best of *Raghus,* for granting success for Hari, approach the mountain which looks like the water-laden clouds. (6)

Lakṣmaṇa. Sire, from the thick foliage, there by the forest must be Kiṣkinda.

Sugrīva. Well has the prince observed:

Well-protected by thy hand, O King, we have now reached Kiṣkinda which is protected by the arms of the Lord of *Vānaras.* Stop, O thou best of men, and I shall with my roar make the world with its moving mountains unconscious. (7)

Rāma. So be it. Go.

Sugrīva. As my lord orders. [*Wandering about*] Ho!

Sugrīva, whom you, O Lord, exiled without reference to his guilt, now wishes to serve thy feet in the field of battle.[5] (8)

4. It is a happy suggestion of the Editor to change the *-api- into -asi-*.

5. Here we may not see any euphemism at all. Sugrīva is evidently more sorry than angry: vide verse 22, note 18.

[*In the postscenium.*]

What! What! Sugrīva, is it?

[*Then enter* Bāli *with* Tāra *holding on to his garment*]

Bāli. What, what, Sugrīva, is it?

O, perfect-limbed Tāre, leave off my clothing? With thy drooping eyes and face, what art thou after? See now that Sugrīva killed in battle with his whole body weltering in blood[6]. (9)

Tāra. Be pleased, be pleased, Your Majesty, Sugrīva would never come with small help. So take counsel with the ministers and then go.

Bāli. Ha!

O, thou who art fair as the moon, let his refuge be Śakra, or the sharp axe-weaponed Śiva, or Viṣṇu whose eyes are like the full-blown lotus-petal; none dare come face to face with me and fight. (10)

Tāra. Be pleased, be pleased, Your Majesty. First Your Majesty deserves to bless this woman.

Bāli. Listen to my exploits:

Tāre, in the days of old when the ocean was being churned, I went and laughing at the hosts of *Suras, Dānavas* and *Daityas,* drew out, to the surprise of all, the terrible-bodied Lord of serpents with his eyes glowing. (11)

Tāra. Be pleased, Your Majesty, be pleased!

Bāli. Ah! Be thou obedient to me.[7] Get inside.

Tāra. Here goes my unfortunate self. [*Exit*]

Bāli. Good, Tāra has gone in. I shall now go and crush the neck of Sugrīva. [*Quickly approaching*] Stop, Sugrīva, stop!

6. In striking contrast is the attitude of Bāli. He is blind with anger and he is moved only by one idea—vengeance for the insult offered to him. The one desires to serve his feet, while the other desires to see his body weltering in blood!

7. Bāli feels annoyed and hence orders Tāra in.

Let Indra be thy aid, or even Madhusūdana ; but having come within my sight, thou shalt not go back alive. (12)

Here ! Here !

Sugrīva. As Your Majesty orders !

[*Both fight a duel.*]

Rāma. Here, here is Bāli :

With his lips compressed and cruel eyes blood-shot, with his arms fisted and teeth bitten, the *Vānara* roaring terribly, shines in the duel like flaming fire, as if desirous of consuming everything. (13)

Lakṣmaṇa. See, Sire, Sugrīva !

With his eyes, like the petals of lotus, glowing red, with his strong arms adorned with golden bracelets, he is now rushing at the Lord of *Vānaras* to attack his own *Guru,* discarding the path of virtue, because he is a *Vānara.*[8] (14)

Struck by Bāli, Sugrīva is fallen !

Hanūmān. Ah, alas ! [*Approaching Rāma with consternation*] Hail, Lord ! This is his fate !

Strong is the Lord of *Vānaras,* but weak is my lord. His condition and your vow—these my sire must remember. (15)

Rāma. Hanūmān, enough of your consternation ! Here do I act. [*Sending an arrow*] Ah ! Fallen is Bāli.

Lakṣmaṇa. This, this is Bāli !

Desirous of entering the abode of *Death,* the strong and broad armed hero with his body bathed in blood and his blood-shot eyes drooping, he is falling down, bolding dragging his body which has become inanimate being pierced by the arrow. (16)

8. The words of Lakṣmaṇa are very interesting. He cannot appreciate the action of Sugrīva in fighting against his *Guru,* but he consoles himself that he is only a *Vānara.* Lakṣmaṇa and Sugrīva form a striking contrast. Even at this supreme moment when Sugrīva is fighting for his life, Lakṣmaṇa is moved by considerations of *Dharma* and this is an indication of his outlook on life.

Bāli. [*Falling into a swoon, reviving, reading the letters of the name on the arrow, addressing* Rāma.]

> Worthy,[9] indeed, of you, O brave Rāma, to kill me in battle thus falsely, you who are a hero, who have no doubt in the righteousness of your action, who are ready to remove deceit in the world, and who profess to follow the path of kingly virtue. (17)

Ha, alas !

> You who are so graceful, you who are the seat of fame. you have this day sown the seeds of ignominy[10] by striking me falsely. (18)

Ha ! Rāghava ! Dressed in barks of trees and thus hiding the purpose of your heart by your dress, is it not unrighteous of you to kill, from behind cover, me who was fighting with my brother ?

Rāma. How is it unrighteous to kill you from an ambush ?

Bāli. What doubt is there ?

Rāma. It is indeed not so. See :

> Depending on cover of traps is the destruction of animals laid down.[11] You are deserving of death and are an animal and hence are you punished and from an ambush.[12] (19)

Bāli. You think me deserving of punishment ?

Rāma. What doubt is there ?

Bāli. For what reason ?

Rāma. For appropriating what should not be appropriated.[13]

9. Rāma is not unknown to Bāli, and hence indulges in a biting sarcasm. One born to remove deceit himself resorts to deceit !

10. This is a perfectly true statement. Vide note 17.

11. Rāma justifies his action by saying that he was only following the mode of attack sanctioned by the *Dharma-sāstras.*

12. Here he gives the reason why Bāli deserves to be punished.

13. This is an interesting statement. Bāli, Rāma interprets, appropriates Sugrīva's wife and justifies himself on the score that it was their peculiar *Dharma.* This is wrong and, therefore, he deserves to be punished. Have we here a suggestion that a wrong thing is always a wrong thing and it can never be made right by any rules of convention ? Here Rāma condemns such an attitude. He upholds the

Bāli. For appropriating what should not be appropriated? That is our *Dharma.*

Rāma. It is proper, is it?

> O king of *Vānaras,* you know what is *Dharma* and what is *Adharma,* and you appropriated your brother's wife, thinking yourself an animal. (20)

Bāli. We are equally faulty in the matter of appropriating brother's wife, and I alone have been punished and not Sugrīva.[14]

Rāma. You have been punished because you deserve it. Who does not deserve it is not punished.

Bāli.

> By Sugrīva was appropriated the legitimate wife of mine, his *Guru's.* By the appropriation of his wife, how do I become punishable, O Descendant of Raghu. (21)

Rāma. It is never like yours[15]—sometimes appropriating the elder brother's and sometimes the younger brother's wife.

Bāli. We have no answer.[16] Punished by you, I am freed of my sins.

Rāma. So be it.[17]

view that a wrong thing is always wrong and it can never be correct by any number of rules. *Dharma* is the same for all and conventions of castes and creeds cannot convert *Adharma* into *Dharma.* This is a point of view that deserves to be well pondered over.

14. Note that if this view is accepted Sugrīva also deserves to be punished, for he also appropriated his brother's wife.

15. Note the distinction made between the actions of Bāli and Sugrīva. This is no doubt a clever distinction, but it sounds more academical than real.

16. Bāli cannot advance any further arguments. But evidently he is not satisfied. He consoles himself by saying that because Rāma has killed him he would have his sins washed away.

17. This statement appears queer. Is it that Rāma himself is not satisfied? He has only succeeded in silencing Bāli in argument. Much discussion has taken place on the subject of Rāma's destruction of Bāli and its justification. In the midst of his distress, Rāma is advised by Virādha to seek the alliance of Sugrīva to gain back Sīta. So when Hanūmān presented himself with his master to Rāma, he readily enters into an alliance, as any human being would in those circumstances. The word of honour having been given, Rāma could not retract therefrom. This seems to be the position that may be taken in interpreting Rāma's position; and it is eminently satisfactory from the human point of view.

Sugrīva. Ha! Fie (upon me)

> Alas, O King of *Haris!* Seeing thy hands, similar unto the trunk of elephants, O elephant-gaited one, with their ornaments gone and lying on the earth, my heart seems to fall.[18] (22)

Bāli. Sugrīva, enough of your sorrows, enough. Such is the course of life.[19]

[*In the postscenium*]

Alas, Your Majesty! Alas!

Bāli. Sugrīva, keep out the women, keep out. In this state I must not be seen.

Sugrīva. As Your Majesty orders. Hanūmān, do so.

Hanūmān. As my prince orders. [*Exit*]

[*Then enter* Aṅgada *and* Hanūmān]

Hanūmān. Aṅgada, this way, this way.

Aṅgada.

> Hearing that the Lord of *Haris* and *Ṛkṣas* has fallen into the hands of *Death*, here I go broken down and overcome by sorrow. (23)

Hanūmān. There is His Majesty:

> Lying on the ground, his heart pierced by arrow, (he) shines like mount Krauñca overcome by the *Śakti* of Guha. (24)

Aṅgada. [*Approaching*] Ha! Your Majesty!

> The Lord of *Haris* was very strong and happy before; but now lies on the bare earth with all his activities gone. Dost thou even now desire to go to the hero's heaven, casting aside thy body pierced by noble arrows? (25)

[*Fall on the ground*]

Bāli. Aṅgada! Enough, enough of your sorrows. Ha! Sugrīva!

18. Sugrīva has not forgotten his brotherly feelings. See note 5
19. Bāli realises his mistake only too late.

[20]Forgetting my faults, casting off your anger and keeping to the path of *Dharma,* receive, O king of *Haris,* him who is the sprout of our race. (26)

Sugrīva. As Your Majesty orders.

Bāli. O, Descendant of Raghu! If these two offend in any way, forgive them their monkey nature.[21]

Rāma. Well.

Bāli. Sugrīva, receive the golden wreath, our family treasure.

Sugrīva. Blessed am I. [*Receive*]

Bāli. Hanūmān, bring me water.

Hanūmān. As Your Majesty orders. [*Going out and entering*] Here is water.

Bāli. [*Applying water*] I feel my breath escaping. Here are approaching the sacred rivers, like the Ganges, the celestial *Apsaras,* like Urvasi, to welcome me. Here is come to carry me the aerial car for heroes, sent by Yama and borne by a thousand swans. Well, I am coming, I am coming!

[*Go to heaven*][22]

All. Alas, alas, Your Majesty!

Rāma. Ah! Bāli has gone to heaven. Sugrīva! Offer him the funeral obsequies.

Sugrīva. As my Lord orders.

Rāma. Lakṣmaṇa, get ready for Sugrīva's coronation.

Lakṣmaṇa. As my sire desires. [*Exeunt all*

20. Notice the parting advise of Bāli. It is eminently befitting the speaker and the hearer.

21. Who are the two here? We would take it as referring to Sugrīva and Aṅgada. These are now the leaders and being but *Vānaras,* are liable to go wrong. So he makes a parting request to Rāma that they may be condoned when they go against *Dharma.*

22. As in the other dramas of the series which may be correctly styled the *Kerala-nāṭaka-cakra,* here is a fight and a death depicted, which is against the accepted canon of Indian dramaturgy. It must have been accepted as such as a result of the limitations of the ancient Hindu theatre. As a matter of fact the foremost difficulty is the removal of the dead body from the stage, particularly in view of the absence of the front curtain. In the present case this difficulty is got over by the description that Bāli goes to heaven. But this only replaces one difficulty by another. How is the flight to be represented? Possibly there might have existed a method of raising up a chariot in air by some mechanical contrivance.

ACT II.

[*Then enter Kakubha*]

Kakubha. The object having been more than half realised,[1] all the *Vānara* leaders are now after their food. Hence I too shall try to get some food. [*Do so*]

Balimukha.[2] [*Entering*] I have been sent by King Sugrīva : ' Out of gratitude for the help rendered by Rāma, the *Vānaras* have been sent in all directions in search of Sīta ; and they have all returned. Learn the doings of Aṅgada who was sent south and return quickly ! ' Where now can the prince be ? [*Wandering about and looking in front*] Here comes the worthy Kakubha. I'll ask him. [*Approaching*] Hope you are doing well.

Kakubha. Ah ! Balimukha, whence art thou ?

Balimukha. Ordered by His Majesty I am come in search of prince Aṅgada.

Kakubha. The worthy Rāma and His Majesty are doing well ?

Balimukha. Yes.

Kakubha. What is His Majesty's wish ?

Balimukha. I have been sent : [*Repeat as before*].

Kakubha. Don't you know that the object has been more than half realised ?

Balimukha. What, what ?

Kakubha. Listen :

> Knowing the whereabouts of Sīta from the king of birds, the son of Vāyu got upon the majestic mountain Mahendra and jumped across the ocean today, thanks to his great strength, for quickly reaching Lanka. (1)

So come along. We shall go to the presence of the prince himself.

[*Exeunt*

Viṣkambhaka.[3]

1. The purpose has been more than half realised because the whereabouts of Sīta were known.

2. He is the messenger sent by Sugrīva to know the progress of the search.

3. The Viṣkambhaka tells us the progress of the story after the death of Bāli and ending with the crossing of Hanūmān to Lanka.

[*Then enter* Sīta *surrounded by Rākṣasa women*]

Sīta. Ah! Fie upon me. My unfortunate self has become very brave; for in spite of the fact that I have been separated from my Lord, that I have been led to the court of Rāvaṇa, King of *Rākṣasas,* and that I have been forced to listen to all unpleasant and undeserving words, suited to his thoughts, I continue to live! Or putting my faith in my lord's arrows, I shall manage to continue to live. Whence, however, can this calmness of mind have arisen now, like that produced in the artisan's hearth by the sprinkling of water. Can indeed my lord be happy at heart in my absence?

[*Then enter* Hanūmān *with the ring in the hand*][4]

Hanūmān. [*Entering Lanka*] Ah! The wonderful disposition of Rāvaṇa's palace!

> With its mansion turrets wrought in gold, with its parks adorned with coral trees, Lanka with its cluster of aerial cars shines like the aerial city of Mahendra! (2)

Ah, indeed!

> Having attained to this unrivalled regal sovereignty, he is now bent upon ruining it by proceeding upon the path of vice. (3)

[*Going on all sides*]

> I have more or less wandered about the whole of Lanka: I have peeped into the interior of the inner apartments, into the halls and aerial cars, into the bath-rooms, into the palaces and mansions of Rāvaṇa, into the drinking halls and private chambers and that many a time; everywhere I have searched, but I do not find my king's wife. (4)

Alas! fruitless has been my work. Well, I shall go up the top of this mansion and look around. [*Doing so*] Here is the *Pramadavana*! I shall get in and search. [*Entering and looking round*] Ah, the wealth of *Pramadavana*! Here indeed:

> Is the place wondrously adorned with numerous big trees wrought in gold and set with blue gems and beautiful with

4. The description following gives an idea of the material prosperity of Lanka.

spotless hillocks—the whole looking like the garden of Indra in heaven. (5)

Further :

I have seen the mountains with their wonderful rivulets and golden mineral ores ; I have seen the lakes graced by numerous water animals ; I have seen the gardens adorned with trees always laden with flowers and fruits. I have seen everything in the abode of Rāvaṇa ; but I have not seen Sīta. (6)

Who can this dazzling being be in this place ? I shall now see : [*Doing so*] Who can this be :

the slender waisted (lady) surrounded by hideous looking *Rākṣasa* women, like lightning flash in the midst of dark blue clouds ?

And she is :

Wearing a single braid of hair like a long dark serpent, she is slender-waisted and is thinking of her lord ; she is emaciated owing to fasting ; her face is stained with tears ; and she is like a lotus-cluster scorched by heat. (8)

Ah ! What can this light be ? [*Looking*] Ah, it is Rāvaṇa !

His head adorned with a coronet set with jewels, his beautiful eyes flushed red, walking gloriously proud and disporting like a rutted elephant, the lord of *Rākṣasas* shines in the midst of young women like a lion diverting in the midst of lionesses.

What shall I now do ? Well, I see. I shall get upon the *Aśoka* tree and hide myself among the branches and know the state of affairs. [*Do so*].

[*Then enter* Rāvaṇa *and his suite*][5]

Rāvaṇa.

I am Rāvaṇa who has by his divine missiles put to flight the hosts of the armies of *Suras, Daityas* and *Dānavas* and who has his breast scrapped by the tusks of the angry celestial ele-

5. Note the lustful Rāvaṇa is given a sensuous setting.

phant and by the Vajra; yet the fair, but indiscreet, Sīta does not like me, but dotes only on that insignificant ascetic of a *Kṣatriya*. Ah! What impediments do Gods create! (10)

[*Looking up*] Here, here is the moon!

There rises and grows in the sky the great lover of lilies, the Moon, shining like a mirror made of silver and crushing my heart with his myriad rays. (11)

[*Wandering about*] Here is Sīta at the foot of the tree wrapt in meditation, emaciated for want of food, well hiding her breasts and her belly, as if desirous of entering into herself, shining in the midst of *Rākṣasa* women like a crescent[6] in a cloudy day, who indeed:

Discarding enjoyments and me and all this prosperity has her heart fixed on that man and is un-yielding. (12)

Hanūmān. Well do I know:

This is that princess, the wedded wife of Rāma, the daughter of (the king of) Mithila, suffering like the terrified deer at the sight of the lion. (13)

Rāvaṇa. [*Approaching*].

Sīte, abandon thy stern vow and come to me, fair maid, discarding now, O, auspicious woman, that man who is dead and who is withdrawn from the path of love. (14)

Sīta. Contemptible is that puny Rāvaṇa; he does not understand the force my words[7] have.

Hanūmān. [*Angrily*][8] Ah, the insolence of Rāvaṇa!

Ignorant of those two arms, of that big bow, and of that arrow of Rāma, he speaks thus, a dead man! (15)

I cannot control my anger. Well, I'll myself finish off Rāma's work. Or:

6. The comparison of Sīta to a crescent is very telling.

7. The editor interprets the text as meaning that Rāvaṇa did not understand the power that Sīta has of defending herself by mere words. See note 10.

8. The insolence of Rāvaṇa makes even Hanūmān angry. Notice the wise conclusion that Hanūmān arrives at.

If I kill Rāvaṇa, the object is accomplished; but if the *Rākṣasa* kills me, a great mission is spoilt. (16)

Rāvaṇa.

O, beautiful-limbed, slender-bodied, and lovely-eyed lady, throw back that dark braid of hair and think of me, O Queen, me who have ten heads and who am adorned with a variety of gems and jewels. (17)

Sīta. Hem, the opposite of virtue flourishes now, since this wicked *Rākṣasa* continues to live.

Rāvaṇa. O, Queen!

Sīta. Thou art cursed.[9]

Rāvaṇa. Ha, ha, ha! The power of the *Pativrata*!

I have routed in battle the *Devas* headed by Indra and the *Dānavas* and yet by these three letters of Sīta have I now been made to swoon.[10] (18)

[*In the Postscenium*]

Hail, Lord! Victory to the Lord of Lanka! Hail, Your Majesty! Hail, great King! The ten *Nāḍikas* are over. It is time for bath! This way, Your Majesty, this way! [11]

[*Exit* Rāvaṇa *with his suite*]

Hanūmān. Rāvaṇa has gone back and sleeping are the *Rākṣasa* women. This is the time to approach the Queen. [*Getting down from the hollow of the tree*] May you live long unwidowed!

I have been sent by Rāma, the King of men, who knows himself and who has his heart enfeebled through love and sorrow for you.[12] (19)

Sīta. Who can this be? Can it be the wicked demon come to deceive me in the guise of a monkey pretending to be my lord's friend? Well, I shall be silent.

9. Rāvaṇa forces Sīta to curse him.
10. See note 7.
11. From this reference it is clear that the scene takes place in the early part of the night. Here is a reference to a bath after 10 P.M.
12. The mode of announcing himself is exceedingly happy.

Hanūmān. The worthy lady does not respond. Enough of your doubts. Listen, madam!

> I am the monkey, named Hanūmān, sent in search of thee by the monkey chief who has allied himself with the light of the Ikṣvāku race.[13] (20)

Sīta [*To herself*] Let him be anybody. Because he has mentioned the name of my lord, I shall talk to him. [*Aloud*] Sir, what news of my lord ?[14]

Hanūmān. Listen, Madam :

> Pale and emaciated owing to long fasting, deprived of the strength of mind, burned by the arrows of the god of love, his eyes filled with tears, he keeps on his wasted body, delighting only in the thoughts of thy noble goodness and loveliness. (21)

Sīta. [*To herself*] Ah, fie upon my unfortunate self : I am ashamed to hear that my lord is suffering thus. Even the love-lorn condition of my lord is fruitful so far as I am concerned, if indeed the monkey speaks true. Listening to my lord's love and toils on my behalf, my heart swings between happiness and misery. [*Aloud*] Sir, how did you come into contact with my lord ?

Hanūmān. Listen, Madam :

> For thy sake, madam,[15] he killed in battle Bāli, the king of *Vānaras,* and made the kingdom of *Haris* over to Sugrīva, O Princess. And by the king were sent monkeys in all directions in search of thee ; one of whom am I come to thee, thanks to the words of the vulture.[16] (22)

And further, it is thus.[17]

Sīta. Cruel, indeed, are the Gods who make my lord suffer thus.

13. Compare this statement with the preceding. He said that he was sent by Rāma and now announces who he was and why he came.

14. Notice the reason why Sīta in spite of her doubts proposes to talk to him. He mentioned her lord's name with respect and reverence.

15. Here Hanūmān makes clear why Rāma killed Bāli. It is for the sake of Sīta, for getting a powerful ally to rescue Sīta from the hands of Rāvaṇa.

16. The reference to the vulture induces greater faith in Sīta.

17. In these words Hanūmān conveys probably the message of Rāma and the symbol of faith. In any case a stage direction should have made this point clear.

Hanūmān. Madam, enough of your sorrows. Rāma indeed:

Carrying the great bow and surrounded by the *Vānara* army, (Rāma) will proceed to Lanka to punish the ten-headed. (23)

Sīta. Can it be a dream I have seen? Sir, is it true? I do not know![18]

Hanūmān. [*To himself*] Ha, alas!

The loving lady knows well her lord; yet weighed down by sorrow, she does not believe in him, as if she was in another body.[19] (24)

[*Aloud*] Madam, I shall now indeed:

O, princess, bring to you here your lord with his excellent bow strung and arrows in his hand. Cast off all thy doubts about me and think yourself by the side of your lord, freed of all thy sorrows. (25)

Sīta. Sir, so inform my lord of my condition that he will not be overcome by sorrow.[20]

Hanūmān. As my worthy madam orders.

Sīta. Go. May thou succeed in thy efforts.

Hanūmān. Blessed am I. [*Wandering about*] How now shall I inform Rāvaṇa of my coming? Well, I shall do so.

Crushing with my hands and foot the Tṛkūṭa garden, the abode of hosts of bees, beautiful on account of lotus and graced with lovely clusters of trees, I shall deprive the Lord of *Rākṣasas* of his pride of material prosperity. (26)

[*Exit*]

ACT II.

18. So great has been her misery and so great is the hope now held out that she naturally is reluctant to believe Hanūmān.

19. Hanūmān realises the situation and so to reassure her promises to bring Rāma there.

20. This is one of the happiest speeches in the whole drama. A more appropriate conclusion for this momentous scene could not be conceived.

Jagannātha Paṇḍita

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(*Continued from Page 244, Vol. III, No. 2.*)

(3) AS A LITERARY CRITIC

Most critics of the Dhvani and Post-Dhvani periods have in detail dwelt upon the classification of Dhvani, without which the full elucidation of the *dhvani doctrine* in literature is not complete. Like Ānandavardhana and Abhinavagupta in the Dhvani period and Mammaṭabhaṭṭa, Vidyānātha, Vidyādhara and Viśvanātha in the Post-Dhvani period, Jagannātha Paṇḍita, the last of the great exponents of *Dhvani* in the Post-Dhvani period has given in his Rasagaṅgādhara a brief yet up-to-date classification of Dhvani with suitable illustrations.

Classification of Dhvani on the basis of suggested sense.

It is admitted on all hands that the most important variety of Dhvani is the Rasadhvani without which no kāvya is a source of pleasure. It is in this sense that the Rasadhvani is called the *viśrāntidhāman*—the chief contributor of pleasure in the form of complete cessation from all activities. The other two well-known varieties of Dhvani—Vastudhvani and Alaṅkāradhvani—do not stand on a par with the Rasadhvani in that they are not by themselves viśrāntidhāmans but they are described as *anyaśābdavailakṣaṇyakārins* (i.e.) they are different from the *Vācyārtha* (primary sense) and the *lakṣyārtha* (secondary sense) and lead, as suggested sense, to a *pāryantikarasadhvani*—culmination of a Rasadhvani. This three-fold classification of Dhvani is *based on the nature of the suggested sense—Rasa* (or *Bhāva*), *Vastu* and *Alaṅkāra*. Here it is to be observed that the term *Vastu* in the phrase *Vastudhvani* is so comprehensive as to include within its scope even *Rasa* and *Alaṅkāra ;* but it is generally taken to mean any *Vastu* (idea) other than Rasa and Alaṅkāra. In the phrase *Alaṅkāradhvani* there is a *paradox*—an Alaṅkāra as an Alaṅkāra cannot be a Dhvani and *vice versa*—which is generally answered by the application of the *brāmaṇaśramaṇanyāya ;* that is, just as a *brāhmaṇa* cannot be a *śramaṇa* but he, once being a *brāhmaṇa,* is converted into a *śramaṇa,* so the *Alaṅkāra,* once an *Alaṅkāra,* is now called a *Dhvani.*

Classification of Dhvani on the basis of vyañjaka (suggestor).

Another well-known classification of Dhvani is based on the *vyañjakas—śabda* and *artha,* the former expressing the latter by the *two potencies, abhidhā* and *lakṣaṇā.* The two main varieties of Dhvani (on the basis of the *abhidheyārtha*) which is popularly known as *vivakṣitānyaparavācyadhvani,* are the *asaṁlakṣyakramadhvani* and the *saṁlakṣyakramadhvani.* The first of these two possesses many varieties—Rasadhvani, Bhāvadhvani, Rasābhāsadhvani, Bhāvābhāsadhvani, Bhāvaśāntidhvani, Bhāvodayadhvani, Bhāvasandhidhvani, Bhāvaśabalatādhvani, etc., where the chief point of interest lies in the fact that it is *akrama*—devoid of any perceptible sequence of time (between the cognitions of the abhidheyārtha (the suggestor) and vyaṅgyārtha (the suggested). In the instance of Rasadhvani the vācyārtha would immediately lead one to the realisation of Rasa : i.e. when the vibhāvas and anubhāvas of the Rasa in question are beautifully described by the poet and when the chief vyabhicāribhāvas are successfully suggested by their own vibhāvas and anubhāvas, the suggestion of Rasa takes place *all at once* and this leads a true *Sahṛdaya* to the *enjoyment* of what is called *Aesthetic pleasure.* Jagannātha has first explained elaborately the dhvanis of all the nine Rasas in suitable illustrations pointing out their vibhāvas, anubhāvas and vyabhicāribhāvas. In the elucidation of Bhāvadhvani he gives *thirty-four* bhāvas which he defines and illustrates in detail. He observes that the difference between the Rasadhvani and the Bhāvadhvani is that in the former the conditions for the suggestion of *Rasa* are very effective, while in the latter they are primarily contributing to the suggestion of a *Bhāva,* though the suggestion of *Bhāva* would ultimately culminate in the suggestion or realisation of Rasa. In such complex instances, Jagannātha says, the context would help us to a considerable extent to decide on its nature.

Bhāvaśāntidhvani, etc., as the Varieties of the Bhāvadhvani.

Jagannātha is of opinion that the varieties of Dhvani—Bhāvaśānti, Bhāvodaya, Bhāvasandhi and Bhāvaśabalatā—are varieties or representations of Bhāvadhvani, since in such cases *bhāva* is to be given the chief place in the body of suggestion, though its particular stages, *śānti,* etc., *are the chief sources of pleasure.* If the *śānti* of the bhāvas is given prominence in the suggestion, then Jagannātha contends, in the instance,

'क्षमापणैकपद्योः पद्योः पतति प्रिये ।
शेमुः सरोजनयना नयनारुणकान्तयः ॥'

(Rasagaṅgādhara, p. 105.)

the *śama* is *expressed* by the verb *śemuḥ ;* but only the *bhāva—roṣa* (*anger*)— is *suggested* by the phrase '*nayanāruṇakāntayaḥ'*; and it would not have, therefore, been called a *bhāvaśāntidhvani.*

The three main conditions of Asaṁlakṣyakramadhvani.

These dhvanis are called *asaṁlakṣyakramadhvanis* under three conditions : (1) *a clear context,* (2) *the easy understanding* of vibhāvas, anubhāvas and vyabhicāribhāvas described by the poet and (3) *the cultured Sahṛdaya,* who no sooner has understood the vācyārtha than he is led to the realisation of Rasa, Bhāva or any other thing.

Bhāvadhvani sometimes Saṁlakṣyakramadhvani (a Vastudhvani) only.

Jagannātha, a close follower of Ānandavardhana and Abhinavagupta, says that if the context is not clear but is to be known after careful consideration of many facts, the *suggestion of the bhāva* that arises there, is only an instance of the *Saṁlakṣyakramadhvani.* Here he quotes Kālidāsa's famous verse in the Kumārasaṁbhava (Canto VI. verse 84):

" एवं वादिनि देवर्षौ पार्श्वे पितुरधोमुखी ।
लीलाकमलपत्राणि गणयामास पार्वती ॥ "

and explains that in this verse the *bhāva—lajjā* (modesty)—of Pārvatī is suggested which is to be understood by taking into account the context, viz., the speech of the Sage (Aṅgiras) to her father Himavān about her marriage with Śiva. The suggestion of *lajjā,* though a *Bhāvadhvani,* is an instance of the *Saṁlakṣyakramadhvani* in that it takes some time for one to understand the context fully. Pārvatī's counting of the lotus-leaves might have been effected by various causes; but the context makes it clear that it is due to her *modesty only* (especially when Sage Aṅgiras opened the topic of her marriage to her father Himavān).

This suggestion of *bhāva* as an instance of *Saṁlakṣyakramadhvani* is further explained by Jagannātha as none other than a *Vastudhvani.* It has been already said that in the Rasacarvaṇā there is necessarily in the cultured spectator a complete absorption of mind and all ideas (except the *svarūpasukhajñāna*) that arise in his mind do vanish. In the instances of Asaṁlakṣyakramadhvanis of Rasa, Bhāva, etc., the Sahṛdaya does not, therefore, experience any sequence between the

vācyārtha and vyaṅgyārtha and this leads him to the immediate realisation of Rasa.[1]

Vyañjanā—a separate Vṛtti.

In the elucidation of the Saṁlakṣyakramadhvani, Jagannātha discusses various view-points regarding the scope of *vyañjanāvyāpāra*—the power of *suggestion*—which is the most essential or vital feature in Kāvya (poetry). Before he gives his own view, he explains the views of some *Prācīnas*.

Prācīna View (1):—One school says that in the use of *homonyms* one may naturally understand more than one meaning, but when only one meaning would suit the context, the other is *not conveyed by the word by its abhidhāśakti,* since the cognition of the context or of the intention of the speaker completely obstructs that of the other meanings by the hearer; and *then by the vyañjanāvyāpāra these śabdas convey the non-contextual sense—the aprākaraṇikārtha.*

This is explained by Mammaṭabhaṭṭa in his verse:—

" अनेकार्थस्य शब्दस्य वाचकत्वे नियन्त्रिते ।
संयोगाद्यैरवाच्यार्थधीकृद्व्यापृतिरञ्जनम् ।।"

(Kāvyaprakāśa, II Ullāsa, Verse 14.)

(१) " प्रकटविभावानुभावव्यभिचारिभिरलक्ष्यक्रमतयैव व्यज्यमानो रत्यादिः स्थायिभावो भवति । रसीभावो हि नाम झटिति जायमानालौकिकचमत्कारविषयस्थायित्वम् । संलक्ष्यक्रमतया व्यज्यमानस्य रत्यादेस्तु वस्तुमात्रतैव, न रसादित्वमिति तेषां (अभिनवगुप्तादीनां) आशयस्य वर्णनेन न तदुक्तीनां विरोधः । उपपत्तिस्त्वर्थेऽस्मिन्विचारणीया । 'रसभावादिरर्थः' इत्यत्र रसादिशब्दो रत्यादिपरः "

(Rasagaṅgādhara, p. 107-108.)

" (उपपत्तिस्त्वर्थे इति) - विभावादिप्रतीते रसप्रतीतेश्च विद्यमानस्य सूक्ष्मकालान्तरत्वरूपस्य क्रमस्य सहृदयेनाकलने तस्य विगलितवेद्यान्तरत्वानापत्त्या रसत्वभङ्गापत्तिः । विगलितवेद्यान्तरत्वञ्च सकलसहृदयानुभवसाक्षिकमिति तवापि सम्मतमिति तदुपपत्तिर्बोध्या ।। "

(Rasagaṅgādharaprakāśa, p. 108.)

"When the *saṁyoga*, etc., restrict the abhidhāśakti (the primary significative potency) of a *homonym* to a particular sense, the knowledge of the *non-primary* (*the non-contextual*) *sense* is possible from the śabda by its *vyañjanāvyāpāra*."

Prācīna View (2):—The other school gives practically the same explanation with *this difference that the understanding of the context does not anyway obstruct that of the aprākaraṇikārtha*; but it emphasises that those śabdas, according to the intention of the speaker, convey only one idea—*the contextual—and the non-contextual idea would be conveyed only by the vyañjanāvyāpāra.*

Prācīna View (3):—Another school holds that both the prākaraṇikārtha and the aprākaraṇikārtha can be known from the word *by its abhidhāśakti* itself and that the cognition of the context or of the intention of the speaker does not in any way hinder that of the uncontextual meaning by the hearer, in view of the fact that the expressions like *payaḥ ramaṇīyam* convey the idea (even to a hearer of an average learning) that *milk and water are nice and beautiful,* though the statement is made in connection with *milk*. And it questions the propriety of a separate potency—*vyañjanā*—to convey the non-contextual sense of a homonym by raising two alternatives: whether vyañjanā is to be accepted in all homonyms or in some only. The first alternative is held to be untenable on the assumption that the knowledge of the intention of the speaker is *not a necessary condition* even for that of the primary meaning and that the *tātparyajñāna* is helpful to the understanding of *a word as correct in its usage.* The second alternative is not accepted on the ground that nothing can be definitely said as the invariable condition for the adoption of vyañjanā. The tātparyajñāna cannot be said to be the basis of vyañjanā (since it is related to abhidhā as well and) since the expounders of vyañjanā accept vyañjanāvyāpāra as *suggestive of atātparyārthas even.* Nor can it be affirmed that the cultured reader possesses an extraordinary *śakti* by which he can appreciate the *suggestiveness* of poetry in the case of beautiful *nānārthaśabdas,* in view of the fact that the same can be said to be conveyed by the *abhidhāśakti* (which produces the arthapratīti in reference to the context). Even the argument that some homonyms (nānārthaśabdas) convey *obscure* ideas by *vyañjanā* as in the example—

'जैमिनीयमलं धत्तेरसनाथामयं द्विजः'

which cannot be conveyed by the *abhidhāśakti* on account of the *bādhapratyaya* (as in the instance—'वह्निना सिञ्चति') falls to the ground since

even in such instances of *bādhapratyaya,* there arises *invalid* śābdabhodha ; otherwise no instance of *atiśayokti* like—

"सौधानां नगरस्यास्य मिलन्त्यर्केण मौलयः"

(which involves such *bādha*) can be satisfactorily explained in its *primary sense.*

Jagannātha's View :—Jagannātha's own opinion on this question is that there is definite scope of *vyañjanā in nānārthaśabdas* if there is *upamā*—similarity and parallelism—between the prākaraṇikārtha and the aprākaraṇikārtha to be suggested. cf. 'प्राकरणिकाप्राकरणिकयोरर्थयोरुपमायान्तु सा कदाचित्स्यादपीत्यत्रास्माकं प्रतिभाति'॥ (Rasagaṅgādhara, p. 116.)

But not satisfied with this scope of vyañjanā, Jagannātha further argues that the power of vyañjanā in a Kāvya can be clearly exemplified by the *yogarūḍha words, when they are also used in their derivative sense.* In such instances neither by abhidhā, nor by lakṣaṇā, do the words convey the derivative sense, *except by vyañjanā.* It is an admitted fact that the yogarūḍhaśabdas convey by their *abhidhāśakti those derivative ideas that are restricted by rūḍhi* : for example, the word *paṅkaja* conveys the idea of *the lotus that is produced from the mud,* and *not other species like the lily* originating from the mud. Nor can it be argued that the derivative ideas are conveyed by those words by the power of *lakṣaṇā,* since there is no ground for *lakṣaṇā,* viz., *absurdity* (*anupapatti*) *of the primary meaning in the context. So the adoption of a third potency of śabda viz., vyañjanā is essential to explain the derivative ideas of a homonym.* Jagannātha sums up this discussion in the verse :—

'योगारूढस्य शब्दस्य योगरूढ्या नियन्त्रिते ।
धियं योगस्पृशोऽर्थस्य या सूते व्यञ्जनैव सा ॥'

(Rasagaṅgādhara, p. 118.)

"When the derivative sense of a yogarūḍha śabda is restricted by the rūḍhi sense, the purely derivative sense of that word is to be conveyed (by that word) by the potency—vyañjanā." He illustrates it by the example :—

" अबलानां श्रियं हृत्वा वारिवाहैः सहानिशम् ।
तिष्ठन्तिचपला यत्र स कालस्समुपास्थितः " ॥

(Rasagaṅgādhara, p. 116.)

" That time is come when the lightnings which have robbed the beauty of handsome females, shine incessantly in the company of clouds." Here the words '*abalā*', '*vārivāha*' and '*capalā*', all *yogarūḍha* words when, taken in their derivative senses, *suggest* the beautiful idea that some unchaste females having stolen the wealth of people who are wanting in strength to resist them, wander in the company of some upstarts carrying water.

Jagannātha has thus analysed the *scope of vyañjanā* both in the *nānārthaśabdas* and in the *yogarūḍhaśabdas* and justified the prācīnas' position in accepting the employment of *vyañjanāvyāpāra* in instances of the nānārthaśabdas without even the upamādhvani, by the statement that the employment of vyañjanā in such cases would save much trouble in the understanding of the non-contextual meaning, though this would not help one in the establishment of the power of vyañjanā—suggestion—as the vital element in a kāvya.

Fourteen conditions deciding the contextual meaning of Homonyms.

In connection with the explanation of the homonyms, Jagannātha, just like Mammaṭabhaṭṭa, elucidates 14 conditions by which the *abhidheyārtha* of a homonym in a sentence is to be determined. They are given in the two oft-quoted kārikās :—

[1]" संयोगो विप्रयोगश्च साहचर्यं विरोधिता ।
अर्थः प्रकरणं लिङ्गं शब्दस्यान्यस्य सन्निधिः ॥

[2]सामर्थ्यमौचिती देशः कालो व्यक्तिः स्वरादयः
शब्दार्थस्यानवच्छेदे विशेषस्मृतिहेतवः ॥ "

Their purport (as given in the latter half of the second verse) is that they help one to understand the really intended idea of the word if there is a doubt on its nature.

Those 14 conditions may be thus briefly noted :—

(1) *Saṁyoga* is the relation or property that is well-known as resting on the object conveyed by the homonym by its abhidhāśakti ;

1. Bhartṛhari's Vākyapadīya, Kāṇḍa II, Verse 317 begins : ' संसर्गो विप्रयोगश्च etc.
2. Bhartṛhari's Vākyapadīya, Kāṇḍa II, Verse 316, runs thus :
' वाक्यात्प्रकरणादर्थादौचित्याद्देशकालतः ।
शब्दार्थाः प्रविभज्यन्ते न रूपादेव केवलात् ॥ '

not only that, it should not be also known as that resting on any other object conveyed by that word (by its abhidhāśakti). In the example, 'सशङ्खचक्रो हरिः' the relation, viz., the contact of one with the two symbols—*śaṅkha* and *cakra*, which is well-known as *resting on Viṣṇu and none else*, determines the sense of the homonym '*hari*' as '*viṣṇu*'.

(2) *Viprayoga* is viśleṣa—removal of that property (described under *Saṁyoga*). In the example ' 'अशङ्खचक्रो हरिः' the idea expressed by the compound 'अशङ्खचक्रः' viz., the removal of the two symbols *śaṅkha* and *cakra* (once existing) determines the meaning of the homonym '*hari*' as *viṣṇu*.

(3) *Sāhacarya* is mutual contact or interdependence in a common cause; for example, in the compound 'रामलक्ष्मणौ' both Rāma and Lakṣmaṇa are spoken of as *mutually related* (by birth and in a common cause); and this relation determines the meaning of the homonym '*rāma*' as the son of *Daśaratha*.

(4) *Virodha* has two aspects: (*i*) the well-known enmity and (*ii*) non-co-existence. The first is generally illustrated by the example— 'रामार्जुनगतिस्तयोः' which refers to two people whose behaviour resembles that of Rāma and Arjuna. Hence the word 'rāma' refers to Paraśurāma (and none else) who is well-known in Indian Mythology as *a great enemy of Kārtavīryārjuna*. The second is illustrated by the example— 'छायातपौ' Here the *non-co-existence between shade and light* is so well-known and so it determines the sense of the ambiguous word '*chāyā*'.

(5) *Artha* is the *fruit* conveyed by *dative case, infinitive*, etc. In the example 'स्थाणुं भज भवच्छिदे' the idea conveyed by the dative case in the word 'bhavacchide' (the fruit, viz., the *destruction of the tie of the saṁsāra*) determines the sense of the word '*sthāṇu*' as 'Śiva'.

(6) *Prakaraṇa* is the context known to both the hearer and the speaker. In the instance 'सर्वं जानाति देवः' when it is said by a servant to a king, the word '*deva*' means only the *king* and none else. Hence the context determines the meaning of the ambiguous word '*deva*'.

(7) *Liṅga* is a symbol or a particular property. It also, when expressed by a word, determines the meaning of a nānārtha word. This

is illustrated by the example 'कुपितो मकरध्वजः' the कोप (anger) conveyed by the word 'कुपितः' determines the meaning of the word मकरध्वजः' as *cupid* and not the ocean.

(8) *Anyaśabdasannidhi* is the usage of two nānārtha śabdas each determining the meaning of the other. In the instance 'करेण राजतेनागः' the words 'करेण' and 'नाग.' both being *nānārthaśabdas* determine the meanings as *trunk* and *elephant* respectively in that the *elephant alone shines with its trunk.*

(9) *Sāmarthya* is causation. In the example 'मधुना मत्तः कोकिलः' (the cuckoo is passionate in the spring season) the cause of passion is the advent of spring. So the word *madhu* means only *vasantartu* (spring season).

(10) *Aucitī* is propriety and capability. It is illustrated by the passage 'पातु वो दयितामुखम्' Here the word *mukha* means *face* of the beloved *in a happy mood,* which alone is capable of pleasing the lovelorn people.

(11 & 12) *Deśa* and *Kāla* are place and time which also determine the meaning of a nānārtha word in a sentence. In the instance 'भात्यत्र परमेश्वरः' the word atra referring to a particular place—kingdom or city—determines the meaning of the word *parameśvara* as the king of that place. Similarly, in the example, 'चित्रभानुर्दिने भाति' the word '*dine*' which means 'in day-time' determines the sense of the word '*citrabhānu*' as the *Sun.*

(13) *Vyakti* is interpreted as the gender of a word. In the instances 'मित्रो भाति' 'मित्रं भाति' the masculine gender of the word *mitra* determines its meaning as the Sun while the neuter gender, as the *friend.*

(14) *Svara* is the accent of a word. In the famous Vedic example—इन्द्रशत्रुर्वर्धस्व, the *antodāttasvara* and the *pūrvapadaprakṛtisvara,* viz., *ādyudātta,* determine the kind of compound: i.e. if it is antodātta, it is *tatpuruṣa* in the sense of the *destroyer of Indra,* and if it is ādyudātta, it is *bahuvrīhi* in the sense of one who possesses Indra as one's *destroyer.*

Further Classification of Dhvani.

After the elucidation of the 14 conditions which determine the meaning of a homonym, Jagannātha further takes up the classification (with illustrations) of the Saṁlakṣyakramadhvani (which is one of the two main varieties of the Abhidāmūlakadhvani). It is first divided into Śabdaśaktimūladhvani, Arthaśaktimūladhvani and Ubhayaśaktimūladhvani. The first is further divided into Vastudhvani and Alaṅkāradhvani and the second, into eight varieties under Vastu and Alaṅkāra and under the varieties of the Vyañjakavastu, etc.—Svastassambhavi, Kavipraudhoktisiddha, Kavinibaddhavaktṛpraudhoktisiddha.

The other well-known variety of Dhvani on the basis of the lakṣyārtha is the *Lakṣaṇāmūladhvani*, more popularly known as the *Avivakṣitavācya*. It is divided into *Jahatsvārthāmūla* (Atyantatiraskṛtavācya) and *Ajahatsvārthāmūla* (Arthāntarasaṅkramitavācya). All these varieties Jagannātha explains and illustrates as well.

(*To be continued.*)

University Notes

OUR VICE-CHANCELLOR

The Government has been pleased to confer the title of Dewan Bahadur on our Vice-Chancellor Rao Bahadur S. E. Runganadhan, M.A., for the distinguished services he has rendered to the cause of higher education in this presidency. While felicitating him on this honour the staff of the University and all those who know him are unanimous in wishing for him more and greater honours.

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CONVOCATION

The fourth Convocation of the University was held on Tuesday, the 30th October, 1934, presided over by His Excellency, the Governor of Madras, the Chancellor of the University. The Address to the graduates was delivered by Dewan Bahadur R. V. Krishna Ayyar, Avergal, B.A., M.L., Secretary, Legislative Council, Madras. On the conclusion of the Address, the Vice-Chancellor delivered a brief speech reviewing the progress and working of the University ever since its inception.

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CONFERENCES

The following members of the staff attended as delegates of the University and read papers at the Conferences noted against each :—

Dr. S. N. Chakravarti	The Indian Science Congress at Calcutta, January, 1935.
Mr. T. S. Raghavan	The Indian Science Congress at Calcutta, January, 1935.
Dr. B. V. Narayanaswami Naidu	The Indian Economic Conference at Patna December, 1934.
Mr. R. Ramanujachariar and Mr. C. T. Srinivasan	The Indian Philosophical Conference at Waltair.

Mr. T. S. Sabhesa Ayyar, Lecturer in Music, presided over the Music Conference held at Madras in the third week of December, '34.

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SPECIAL LECTURES

The following Special Lectures were delivered since the last issue:—

Mr. T. N. S. Raghavan	Bacteria in Daily Life. Insects and human life.
Mr. V. R. Ramachandra Dikshitar	War in Ancient India (5 Lectures).
Prof. Norman Brown of Philadelphia University	Early Western Indian Miniature Painting.

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BUILDINGS

The construction of a Men's Club and the Music College has been sanctioned by the Syndicate.

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The Founder-Pro-Chancellor made a generous gift to the University of a spacious building constructed at a cost of Rs. 15,000 for use as Ladies' Club. Her Excellency Lady Beatrix Stanley opened the Club Buildings on the 30th October, 1934.

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RESEARCH

Besides a large number of extension lectures delivered by the members of the Teaching Staff the following members have submitted papers to various Conferences and Journals:—

MR. R. RAMANUJACHARIAR.

Yamunacharya's Refutation of Dehatmavadaat (Tenth session of the Philosophical Congress).

MR. P. S. NAIDU.

1. On Locke and critical Realism.
2. On the Doctrine of Redemption according to Lokacarya. (Tenth session of the Philosophical Congress).

MR. C. T. SRINIVASAN.

Into Matrix of Memory. (Tenth session of the Philosophical Congress).

MR. S. K. GOVINDASWAMI.

1. Some problems of the reign of Rajadhi Raja II.
2. A note on a Pala image of Ganapati at Kumbakonam. (Journal of Indian History).
3. Chola Painting. (Journal of the Indian Society of Oriental Art Part II).

PROFESSOR C. S. SRINIVASACHARIAR.

1. Baroda and its South Indian Dewans. (Sayaji Rao Gaekwar Diamond Jubilee Commemoration Vol.)
2. The Historical material in the Diary of Anandaranga Pillai (1736-61) Two chapters. (Journal of Indian History).

DR. B. V. NARAYANASWAMI NAIDU.

1. Some aspects of Economic Planning. (The Eighteenth Indian Economic Conference).
2. Agricultural Marketing in India. (Madras Agricultural Conference).

MR. B. RAMAMURTI.

1. On the rank of a quadric related to the rational norm curve. (Journal of the London Mathematical Society, Vol. 9).
2. On quadrics poristically related to a rational norm curve. Proc. Camb. Phil. Soc. Vol. 30).
3. A covariant specification of the simplex inscribed in a rational norm curve in a space of odd dimensions and circumscribed to a quadric inpolar to the curve. (Journal of the Indian Mathematical Society XX).

DR. S. SIVASANKARANARAYANA PILLAI.

1. On the sum function of the number of prime factors of N. (Journal of the Indian Mathematical Society XX).

MR. S. SUBRAHMANYAN.

1. On Synges paper. (Bull. Academy Sc. U. P. III 2).
2. On a certain condition of Frish's—(Journal of American Statis. Association September, 1934).
3. Deviazione geodetica in uno spazio a curvature constante (Boll. Unione Math. Italiana XIII-4).

DR. S. R. RAO.

1. The secondary structure in crystals. (Current Science Vol. II, p. 281).
2. Diamagnetism of organic liquid mixtures. (Indian Journal of Physics, Vol. 8, p. 483).
3. Magnetism of Tin. (Nature Vol. 134, p. 288).

DR. S. R. RAO AND P. S. VARADACHARI.

1. Diamagnetism and molecular association in organic liquids. (Current Science Vol. 2, p. 475).

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2. Diamagnetism of organic liquid mixtures at different temperatures. (Proceedings of the Indian Academy of Sciences, Vol. I, p. 77).
3. Magnetic properties of organic vapours. (Nature, Vol. 134, p. 812).

DR. S. R. RAO AND MR. G. SIVARAMAKRISHNAN.

A new method of determining the magnetic susceptibilities of gases and vapours. (Proceedings of the Physical Society, London, Vol. 46, p. 318).

DR. S. R. RAO AND MR. S. SRIRAMAN.

Diamagnetism of nitrobenzene at different temperatures. (Indian Journal of Physics Vol. 8 p. 315).

DR. S. N. CHAKRAVARTI AND MR. M. SWAMINATHAN.

1. A synthesis of 2 : 3—Methylenedioxy-11 : 12 dimethoxy-tetra hydroprotoberberine, an isomer of tetrahydroberberine and a synthesis of 2 : 3 : 11 : 12 Tetramethoxytetrahydroproto berberine, an isomer of Tetrahydropalmatine. (Journal of Indian Chemical Society, 1934, II, 107-115).
2. Synthesis of 5 : 6 Dimethoxyhomophthalic acid and of some monomethoxy homophthalic acid. (Journal of Indian Chemical Society, 1934, II, 101-107).
3. O-Aldehydo-carboxylic acids. Part I. A new general method of synthesis of Phthalomic Acids. A synthesis of ψ-opianic acid and a new synthesis of M-opianic acid. (Journal of Indian Chemical Society, 1934, 715-720).

MR. T. S. RAGHAVAN.

Somatic Chromosomes of Virginea Indica. (Journal of Indian Botanical Society).

MR. R. V. SESHAIYA.

1. The Anatomy of Paludomus Tranchurica. (Records of the Indian Museum Vol. XXXVI. Part II. June, 1934).
2. A further note on the style sacs of Gastropods. (Records of the Indian Museum, Vol. XXXVI. Part II. June, 1934).
3. The anatomy of the Indian Melaindae. (Indian Science Congress, January, 1935.)
4. The anatomy of Rachisellus practermissus. (Indian Science Congress, January, 1935).

MR. A. RAMAKRISHNA REDDY.

The gastric armature of South Indian Decapod Crustacea.

Notes

A NOTE ON THE RANDOMNESS OF THE DIGITS IN π[1]

BY

G. V. KRISHNASWAMI AYYANGAR

(Annamalai University)

When Mr. Venkatachari came to me with this problem set to him by professor Narasinga Rao, I was not aware that it has been dealt with before. While going through the volumes of the Journal of the Royal Statistical Society in another connection, I came across the Presidential Address to the Society by Edgeworth[2] in which a reference is made to this problem. This naturally led to other references. As some of these references are now out of print and generally also on account of the interest of the problem, I am briefly noting them here.

De Morgan seems to have expressed doubts about the truly random character of the digits which constitute the ratio π by examining the first 608 digits.[3] Jevons has gone so far as to ask, "Why should the value of π, when expressed to a great number of figures, contain the digit 7 much less frequently than any other digit ?"[4] Dr. Venn discusses the question whether there is any unusual divergence from *a priori* chance by examining the following problem as being more appropriate to the science of probability, viz: "Assign the degree of improbability of the event in question, (i.e.) its statistical rarity" and judge whether this improbability gives rise to any grounds of suspicion. By the usual methods of calculation the chances against an excess or defect of 18 from the fair average 70 are about 49 to 1 in respect of any specified digit.[5] But Dr. Venn observes that "of course what we want to decide are the chances against *some one* of the ten* showing

1. Journal of the Annamalai University, Vol. III, No. 2, pp. 205-207.

2. Journal of the Royal Statistical Society, Vol. 76 (New Series), 1912-13; p. 165, etc. Presidential Address of Professor F. Y. Edgeworth on the Use of the Theory of Probability in Statistics relating to Society.

3. De Morgan, Budget of Paradoxes, p. 291.

4. Jevons, Principles of Science, p. 529.

5. See S. Venkatachari, The Sequence of Digits in π, Journal of the Annamalai University, Vol. III, No. 2, § 4.

* *at least.*

this divergence."[6] This can be approximately determined by the fraction $(49/50)^{10} = \cdot 817$ about. This represents odds of only about 9 : 2 against such an occurrence which is nothing remarkable.

Mr. Edgeworth gives the rationale of the "paradox" adduced by De Morgan in his Budget. The probability of divergence between theory and fact usually calculated relates to the occurrence considered as a single event. When there are several trials, the probability of failure in some one trial becomes serious. "If you go on exposing yourself to risk you must expect to get hit."

It would be interesting to notice that while the digit 7 occurs 51 times in the first 700 figures of the expansion as given by M. de Montessus de Ballore, it also occurs 51 times in the first 690 figures; it occurs 52 times in the first 707 figures and 53 times in the first 708 figures.[7]

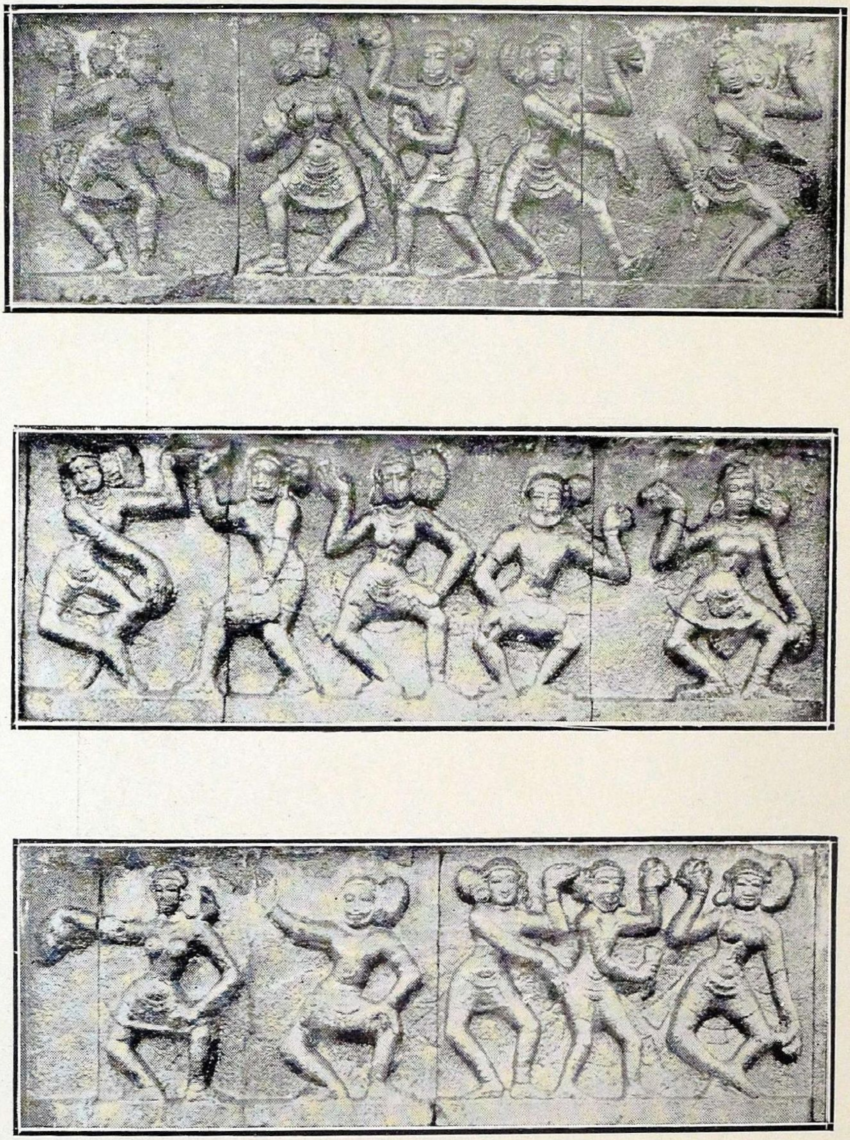
Perhaps a word may be said about the randomness of the arrangement of the figures in the expansion. "If we look to the process of production of these digits no extremer instance can be found of what we mean by the antithesis of randomness; every figure has its necessarily preordained position, and a moment's flagging of intention would defeat the whole purpose of the calculator. And yet, if we look to results only, no better instance can be found than one of these rows of digits if it were intended to illustrate what we practically understood by a chance arrangement of a number of objects. Each digit occurs approximately equally often, and this tendency develops as we advance further; the mutual juxtaposition of the digits also shows the same tendency. . . . In fact, if we were to take the whole row of hitherto calculated figures, cut off the first five as familiar to us all, and contemplate the rest, no one would have the slightest reason to suppose that these had not come out as the results of a die with ten equal faces."[8] Dr. Venn has also given a graphical display of the succession of digits in π; and so far as the eye is a guide the arrangement answers quite fairly to the description of randomness.[9]

6. Venn, Logic of Chance, p. 248, where he considers the number of sevens in π expressed to 708 decimal places.

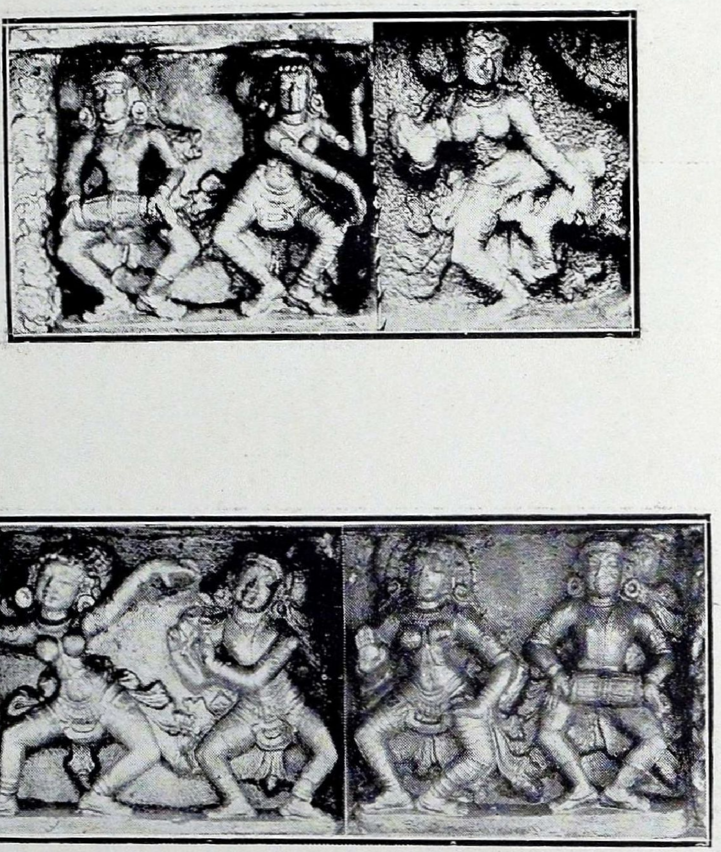
7. See the value of π given by Mr. Shanks in the Proceedings of the Royal Society of London, Vol. 21, p. 319. He has calculated π to 707 places from $\tan^{-1} 1/5$ and $\tan^{-1} 1/239$. The several digits in these two magnitudes calculated to 709 places are given there. They show the same divergencies.

8. Venn, p. 111.

9. Ibid., p. 114-115 for method and p. 118 for figure. The numbers 0—7 are taken each to represent one of the eight points of the compass. Neglecting the first figures the sequence of the digits 0—7 in the expansion indicate the sort of path along which one should travel by these steps.



Some Dance Poses inside the Chidambaram Temple.



Some Dance Poses inside the Chidambaram Temple.

A NOTE ON SOME SCULPTURED DANCE POSES IN THE INNER PRECINCTS OF THE CHIDAMBARAM TEMPLE.

BY

B. V. NARAYANASWAMY NAIDU AND P. S. NAIDU

The Madras Epigraphical Report for 1914 draws attention to the existence of the dance poses in the Eastern Gopuram of the Chidambaram temple. Mr. Manavalli Ramakrishna Kavi, M.A., the editor of *Nāṭyaśāstra,* says : " In the compartments of the east and west gopuras in the Natarāja temple at Chidambaram in South India these *karanas* were cut on rocks with appropriate verses from the *Nāṭyaśāstra* underneath each of the postures. . . . The Government Department discovered their existence and reported this with the illustrations in the Madras Report for 1914." [1]

We wish to point out that these dance poses occur not only in the Eastern and the Western Gopurams, but also in the Northern and Southern Gopurams, in the hall of 1,000 pillars, in the temple of Sivakami Amman, in the Nritta Sabha, in Sri Subramania's Shrine, in fact, in the ceilings and walls, of every structure in the temple. These dancing figures meet one at every turn, and the entire shrine is, as it were, snowed in under a plethora of the sculptured dance-poses.

Fergusson, in his " History of Indian and Eastern Architecture ", writes : " The oldest thing now existing here is a little shrine in the inmost enclosure. . . . A porch of fifty-six pillars about 8 feet high, and most delicately carved, resting on a stylobate, ornamented with dancing figures, more graceful and more elegantly executed than any others of their class, so far as I know, in Southern India. . . . Whitewash and modern alterations have sadly disfigured this gem, but enough remains to show how exquisite, and consequently how ancient, it was." [2] Jagadisa Ayyar, while quoting the above passage from Fergusson, remarks : " The *Nritta Sabha* has fine sculptural representations in its base. . . . The fine architectural carvings, which attract the eye of every one, are on the niches of the four main outer gopuras. These contribute, in a great measure, to the greatness of the temple." [3]

We have photographed and reproduced here some of the graceful and elegant poses mentioned by Fergusson. Further work on the subject is proceeding.

1. M. R. Kavi, M.A. : Nāṭyaśāstra, pp. 11-12.
2. Fergusson : History of Indian and Eastern Architecture, pp. 374-75.
3. Jagadisa Ayyar : South Indian Shrines, p. 206.

Reviews

Banking Law and Practice in India.—By M. L. Tannan, M.Com., Bar-at-Law, I.E.S., Butterworth and Co. (India), Ltd. Pages 601, price, Rs. 15.

This well-known writer who was Professor of Commerce in the Sydenham College of Commerce and Economics, Bombay, and who is now Secretary, Indian Accountancy Board and Under-Secretary, Department of Commerce, Government of India, has brought out a second edition of his book on Banking Law and Practice in India. It has been considerably revised and enlarged and the new volume includes the latest rulings of the Courts of England and India on many fundamental issues thus making the book up-to-date. This is one of the best books written on the subject.

The introduction deals with the history of banking in India. The learned author points out that the Negotiable Instruments Act in India is not comprehensive, in spite of the fact that the Act was amended several times. The author next deals with the relation between banker and customer, banking organisations and kindred topics. The advantages of cheque currency are clearly discussed and a plea made for the popularisation of the cheque habit in India. Mr. Tannan points out that in India there is one banking office for every 484,066 persons while in the United Kingdom there is one to every 4,816 persons. Hence arises the need for opening more banking offices in India. Chapters VI and VII are devoted to such topics as bankers' responsibilities regarding the payment of customers' cheques, the duties of collecting banks, the pass book and its uses, recovery of money paid by mistake, and the manner of closing customers' accounts. The closing chapters describe the nature of the bank's investments and also other services that a bank can render.

Throughout the book stress is laid on the practical aspect of the subject and the relevant statutes and specimen forms given in the appendix increase its usefulness. The information given is precise and accurate, the style easy and lucid. The presentation is clear and scholarly. This work is of inestimable value to all those interested in the theory and practice of banking in India.

B. V. NARAYANASWAMY.

NAVEENATARKAM.

'Naveenatarka', the first Tamil publication of the Annamalai University is an interesting venture and welcome addition to the Tamil Literature. It is a compendious, yet fairly comprehensive introduction to the study of Aristotelian or European system of Logic in Tamil. Logic is, of course, one of the abstract sciences of indigenous origin in ancient India, fully developed and highly advanced centuries ahead of many other countries of the civilised world; and Tamil Language counts more than one treatise on Logic, either translations or adaptations from the Samskrit originals. Yet they are all conceived, designed and presented in the old scholastic or doctrinaire style, and are meant and mostly studied for purposes of theologic polemics. They are often coloured by the several religious and religio-metaphysical objectives, if not predilections, of their authors. Both their architectonics and execution, spirit and style are too theologic, obstruse and doctrinal, if not artificial, to serve the common taste and ordinary requirements of students of cosmopolitan culture. Without any disparagement to the indigenous systems, we could well wish to see our vernacular literature enriched and engrafted with the best fruits and studies of other systems of thought. Comparative studies are always healthy, and will be very useful. They will invigorate and promote any culture. And no patriotic Tamilian will be guilty of the arrogant presumption that the Tamil Literature is above improvement in any sphere.

In the field of Logic in particular, where the books are none of them original or indigenous, secular or non-sectarian in the Tamil Literature, the publication of this 'Naveenatarkam' by the new Tamil University founded by the great South Indian philanthropist should receive more than ordinary welcome. It is as patriotic in purpose, as it is propitious in the present stage of this University's history. The University authorities have deservedly earned the grateful appreciation of Tamil India by promoting and publishing this book.

The author of this Book, Mr. K. R. Applachariar, Philosophy Lecturer in the Government College in Coimbatore, is to be warmly congratulated for this good book, which augurs well for the success and enterprise of the Annamalai University in the field of new publications. That a new Tamil Logic should be the very first publication of this only Tamil University in India is as appropriate as it is praiseworthy.

The book admits of course of possible improvements both in matter and manner. As a first attempt in a novel field, the author himself cannot and would not claim for it perfection. But that it is a superb model for pioneers in other fields of knowledge is indisputable. Avoiding

pedantry and obstruseness alike, the book aimed at and achieved considerable success in simplicity of style, and clarity and perspicuity in content. The author's verve and wisdom in adapting and coining Sanskrit-terms and terminology for his new book of Logic in Tamil are commendable. They are often aptly expressive and suggestive; and what is even more important, they conform to the honourable and long established traditions sanctioned in the Tamil Literature. The author steers clear of the two extremes (1) of Kleptomania by importing wholesale or by merely transliterating all the foreign or English terms of Logic, as they are, in the Tamil book, or (2) of megalomania by inventing all sorts of clumsy, ill-expressive, novel Tamil phraseology bordering on obscurantism. It may be desirable to avoid disfiguring Tamil with morbid *manipravalam* style, and to minimise resort to Sanskrit terms to the barest and sanest limits of necessity and lucidity. But it is nothing to be regretted that Sanskrit is a handy stand-by reserve freely to bank upon to meet urgent requirements and fresh needs to develop Tamil Culture on new lines. It has the sanction of time and usage; and it will offer no violence to the genius and traditions of Tamil. The Language of the book is both simple and sweet, clear and forceful. It even exhibits a veiled vein of natural humour, always welcome in a treatise on an abstract science. An advanced Tamil scholar may have reduced the number of Sanskrit terms used, and suggested some equally happy Tamil substitutes. The Tamil Literateur may have easily used a more elegant and polished diction. But these are not indispensable in a primer or book of introduction in Logic. On the whole, the book is such that one may well say 'Leave the well alone'. The appearance of such a treattise is both a desideratum and a provocateur. It supplies a felt want, and is calculated to encourage and promote fresh thoughts and attempts in new fields of knowledge in Tamil.

It will take some wind out of the sail of those who ever trot out the bogey of want of good text-books in Tamil in branches of scientific knowledge. And by introducing the leaven of this current European system of Logic, and by creating this new impact of thought, this book is to be hoped to serve to sharpen and fertilise the incisive and astute South Indian intellect, stimulate Tamilian enterprise, and to forge newer links and chains in many a field of scientific knowledge in Tamil. I commend the 'Naveenatarkam' to the Tamilaham as a brave if not bonny, a vigorous if not an elegant enterprise, deserving recognition and appreciation at the hands of all lovers of Tamil culture, both the academicians and the lay students; and I wish it all success.

S. S. BHARATI.